A WATER QUALITY ASSESSMENT OF LAKE ERIE HARBOURS

A REPORT PREPARED FOR
MINISTRY OF THE ENVIRONMENT

BY PROCTOR & REDFERN LIMITED
75 EGLINTON AVENUE EAST
TORONTO, ONTARIO
M4P 1H3

OCTOBER 1981

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1.0 SUMMARY AND RECOMMENDATIONS

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Rondeau Harbour

Of all the harbours of Lake Erie considered during this study, Rondeau was the most important from a recreational viewpoint. Water quality was rated as fair to poor for water contact recreation mainly because of a lack of water clarity. Bacterial contamination was not a problem in this harbour although this has been reported as a concern in the past.

The available data indicated that Rondeau Harbour is mesotrophic during most of the year. Agricultural activities were implicated as probable sources of nutrients. High levels of iron were found, well in excess of Provincial and International objectives. Sources of this iron and its impacts on local biota were not determined. It is interesting to note that all harbours studied in the western Lake Erie basin showed very high levels of iron, while those in the eastern basin did not.

Port Stanley

Almost all parameters examined within the inner harbour showed signs of water quality impairment. Nutrient levels were high, turbidity levels high, visibility poor and bacterial levels very high. Analysis of historical data revealed that water quality has deteriorated within the inner harbour betwen 1967 and 1979. Water quality in Lake Erie outside of the harbour has remained relatively constant during this same time period.

Reasons for the noted deterioration of water quality were not determined during the present study. Presently Port Stanley has the most degraded water quality of any port examined. Due to this impairment the waters were thought to be unsuitable for water contact recreational activities and public water supply. The water was also considered detrimental to aquatic organisms.

Port Burwell

Water quality within this harbour was also found to be poor. High levels of phosphorus and chlorophyll led to classifying this harbour as moderately eutrophic. Nitrogen compounds were mainly in the form of stable nitrates indicating a remote source for these nutrients. Water clarity was poor and bacterial levels exceed objectives, two factors which limit water contact recreational activities in this harbour.

Port Dover

Water quality within Port Dover harbour is impaired and has been impaired since at least 1975. Nutrient levels were considerably higher inside the harbour, dissolved materials elevated and transparency reduced. Station 132, which was located in Lake Erie off Port Dover had very good water quality. Except for heterotrophic bacterial levels which were quite high, data from this station indicate oligotrophic conditions. Unfortunately samples of coliform and pathogenic bacteria were not obtained for this station. All parameters which were examined, however, indicate water of good quality suitable for recreational activities and public water supply.

Port Colborne

Water from Lake Erie flows into Port Colborne and thereby enters the Welland Canal. Consequently, transect data obtained reflect conditions within the eastern Lake Erie basin and are not influenced by watershed activities. Water quality in Port Colborne was very good. Nutrients were low, clarity and oxygen saturation high, and bacterial populations small.

Water quality data indicated this harbour to be oligotrophic. No limits to aquatic life nor restrictions to recreation or public water supply were found.

2.0 INTRODUCTION

2.0 INTRODUCTION

2.1 Background

As part of the Lake Erie intensive survey of GLISP (Great Lakes International Surveillance Plan), water quality data was collected from five Lake Erie harbours by the Ontario Ministry of the Environment (MOE). This 1978 and 1979 data has been summarized by Proctor & Redfern Limited (P&R) and is the subject of the following report. It should be noted that only surface (1 metre) water quality data are reported in this document.

2.2 Objectives

The objective of this study was to assess the status of enrichment and the extent of local water quality impoundment at a number of harbours in Lake Erie. This information will be used for the identification of existing or emerging water use conflicts from which water management policy can be formulated.

2.3 Methods

The analytical methods of sample analysis utilized by the MOE Toronto laboratories are outlined in this section.

Nutrients and Productivity

Ammonia

A filtered portion of the sample is presented to the Auto Analyzer where, as one of four concurrent tests, a proportioned aliquot is withdrawn into the ammonia manifold. For the color formation stream, a phosphate buffer, alkaline phenate reagent, commercial chlorine bleach, and sodium nitroprusside are proportioned in turn into the sample stream which is already segmented with air. The reaction rate is increased and stablized by elevating the temperature to 37.5°C. The blanking stream differs from the color formation stream in only one respect: the nitroprusside catalyst is replaced by an equal flow of DDW. The absorbance of the blue indophenol

species (which is formed in proportion to the concentration of ammonia in the sample stream) is measured colorimetrically at 630 nm using 5 cm flow cells. Two analytical ranges are obtained from the output of the AAII colorimeter. The result in mg/l nitrogen is read from the appropriate chart recorder trace by comparison with peaks produced by similarly treated standards.

Total Kjeldahl Nitrogen

An unfiltered aliquot (50 ml) of sample is mixed with sulphuric acid and boiled unit fuming occurs. After cooling and addition of potassium persulphate (an oxidizing agent), the sample is fumed for an additional 20 minutes. The sample is then redissolved in a small portion of de-ionized distilled water, neutralized to the methyl red endpoint, diluted to 50 ml and transferred into AutoAnalyzer tubes. After automatic proportioning of the sample into the TKN ammonia channel, the stream is air segmented, hypochlorite and phenate are then sequentially added with mixing. Absorbance of the indophenol complex is measured at 630 nm using a 5 cm flow cell in the colorimeter. TKN concentration is obtained by comparing sample peak heights to those of a similarly treated set of standards and blanks.

Nitrate & Nitrite

A filtered portion of the sample is presented to the AutoAnalyzer, where, as one of four concurrent tests, a proportioned aliquot is withdrawn into the nitrate channel either directly or through a dilution loop as required. EDTA reagent is mixed with the sample and then passed through a column of cadmium metal filings where nitrate ion is electrochemically reduced to nitrite ion. After passing through the cadmium column, the sample stream is segmented with air and colour reagent containing a-naphthylamine and sulfanilic acid to form a diazotization product which couples with the naphthylamine. Bufferring the solution to a pH of approximately 3.7 produces a light red chromophore in proportion to the concentration of nitrite that is produced by the reduction of nitrite. The absorbance of the solution is measured colorimetrically in a 5 cm flow cell at 520 nm. The concentration of nitrite plus nitrate on the recorder trace against

those obtained from a similarly tested series of standards.

Total Phosphorus

An unfiltered aliquot of sample is mixed with sulfuric acid and boiled until fuming occurs. After cooling and adding an oxidizing agent (potassium persulfate), the sample is fumed for an additional 20 minutes prior to neutralizing to the methyl red endpoint and diluting to volume. The digested sample is transferred to AutoAnalyzer tubes, proportioned into the phsophorus channel, air segmented and mixed with an acidic molybdate solution. Stannous chloride is added to reduce the phosphomolybdic acid complex to the heteropoly blue species. The absorbance of the test solution is measured in a colorimeter with a 5 cm flow cell and 660 nm interference filters. The concentration of total phosphorus is obtained by comparison of sample peak heights with those obtained from a similarly treated series of standards and blanks.

Filtered Reactive Phosphorus

A filtered portion of sample is presented to the AutoAnalyzer where a proportioned aliquot is withdrawn into the phosphate channel either directly or through a dilution loop as required. The air segmented sample stream is mixed with molybdic acid reagent to produce a yellow phosphomolybdic acid complex with the orthophosphate present in the sample. Stannous chloride is added to reduce the complex to the heteropoly blue species. The absorbance of the test solution is measured in a colorimeter with a 5 cm flow cell and 660 nm filters. The concentration of orthophosphate in the original sample is obtained by comparing sample peak heights with peak heights obtained by a similarly treated series of standards.

Silicate

Silicates react with ammonium molybdate at pH 1.2 to produce a yellow molybdosilicic acid complex. The yellow complex is reduced to produce the blue chromophore which is more stable and more intense in colour. The absorbance of the solution at 660 nm is directly proportional to the concentration of silicates which react with molybdic acid under the test

conditions.

This method measures silicon which is present in the sample as the reactive silicate ion (SiO_3^{2-}), plus any form of silicon which can be hydrolysed to form this ion under the conditions of the test. The degree to which acid and other hydrolysis occurs during the test is unknown, but believed to be small.

Chlorophyll A

The UNESCO spectrophotometric method is currently employed in our laboratory. Chlorophyll is extracted from plant tissue using a 90% acetone solution and absorbances are determined at 750, 665, 645 and 630 mu. The UNESCO equations are used to calculate chlorophyll A and b. Any other pigments or degradation products which absorb at these wavelengths will be included as an interference.

Corrected Chlorophyll A

Pheophytin is a natural degradation product of chlorophyll and often in phytoplankton. Pheophytin A, although physiologically inactive, has an absorption peak in the same region of the visible spectrum as chlorophyll A and can be a source of error in chlorophyll determinations. In nature, chlorophyll is converted to pheophytin upon the loss of magnesium from the porphyrin ring. This conversion can be accomplished in the laboratory by adding acid to the pigment extract. The amount of pheophytin A in the extract can be determined by reading absorbance before and after acidification saturation concentration of oxygen in water at the same temperature is obtained to the observed charts and compared to the observed concentration. Results are then expressed as percent saturation.

<u>Transparency</u>

Turbidity

The turbidimeter is a nephelometer standardized against turbidity standards.

A nephelometer operates on the principle that light in passing through a substance is scattered by any particulate matter which may be present. The degree of scattering is directly porportional to the turbidity present.

In the turbidimeter, a strong focused light beam is directed upward through a cell containing the sample. A fraction of the light scattered at $90^{0} \pm 30^{0}$ to the incident beam by the particulate matter in the sample is detected by a photomultiplier tube. The electrical signal produced is displayed on the instument's meter which is calibrated to read directly in Formazin turbidity units (FTU). Calibration is accomplished with a standard suspension of Formazin polymer.

Metals

Iron

Iron is brought into solution and reduced to the ferrous state by boiling with hydrochloric acid and hydroxyl-amine hydrochloride, then treated with 1,10 pehnanthroline at a pH of 3.1 to 3.5. Three molecules of phen-anthroline chelate each atom of ferrous iron to form an orange-red complex. The coloured solution formed obeys Beer's Law; its insensity is independent of pH from 3 to 9 and is stable for at least six months. A pH between 2.9 and 3.5 ensures rapid colour development in the presence of an excess of phenanthroline.

Iron concentrations between 0.05 and 3.5 mg/l are measured directly, while higher concentrations are determined by the use of smaller sample aliquots.

Microbiology

Total Coliform, Fecal Coliform and Fecal Streptoccoi

In analysis of water pollution indicator bacteria, the membrane filter procedure is utilized. Each bacterial cell deposited on the membrane filter and given a suitable nutrient source has the potential to grow and multiply sufficiently to form a bacterial colony with distinguishing characteristics to permit a differential count being made.

Depending on the density of bacteria in the sample, and hence the number of dilutions required to obtan plates suitable for counting, the analysis time for one sample would range from 5-10 mintues. Incubation time for the total coliforms is 22 $\pm$ 2 hours. Incubation time for fecal coliforms is 20$\pm$ 1 hour and for fecal streptococci, it is 48 $\pm$ 3hours.

2.4 Interpretation of Data

Water quality studies are undertaken in order to define environmental conditions and changes with time. Of particular interest to this study was the relationship between observed water quality and Provincial and Great Lakes Water Quality Agreement objectives. The following section notes the significance of each water quality parameter examined and outlines current objectives.

Nutrients and Productivity

Ammonia

Ammonia nitrogen is usually present in domestic wastewaters, and often found in industrial effluents. Moreover, biochemical reduction may produce ammonia in groundwaters. The ratio of free ammonia (NH_3) to ammonium ions (NH_4^+) is dependent upon the water's pH value. Ammonia nitrogen may also be present in the form of a metallic ion complex.

In the NH_3 form, ammonia nitrogen is particularly toxic to fish, and all forms exert a high oxygen demand when converted to nitrite/nitrate. Ammonia nitrogen interferes with water treatment procedures by reacting with chlorine to form chloramines.

Since the ionization of ammonia is dependent on pH, and the un-ionized ammonia ion is the toxic form, the Provincial objective for un-ionized ammonia is 0.02 milligrams per litre. This level has been set for the protection of aquatic life.

Agreement Objectives state: concentrations of un-ionized ammonia (NH_3) should not exceed 0.020 milligrams per litre for the protection of aquatic life. Concentrations of total ammonia should not exceed 0.50 milligrams per litre for the protection of public water supplies.

Total Kjeldahl Nitrogen

Since nitrogen is one of the five principal constitutes of living matter, its form and concentration is of major interest when dealing with the growth of organisms in the aquatic environment. In nature, it may be found in a number of forms (organic nitrogen compounds, ammonia, nitrite, nitrate as well as nitrogen and microbiological conditions. These species thus constitute the well-known nitrogen cycle. Analytical methods have been developed to distinguish between them. Total Kjeldahl nitrogen (TKN) includes the organic nitrogen compounds (soluble and particulate) plus the ammonia fraction.

TKN concentrations may range from less than 0.1 mg/l in extremely "clean" environments to over 50 mg/l for wastewaters. Though not always the case, the organic nitrogen component of TKN usually constitutes the greater fraction for uncontaminated surface waters while the ammonia component is more significant in groundwater and wastewater samples.

Sewage and industrial waste treatment effluents and runoff from agricultural areas (where fertilizers have been used) are the primary sources of TKN beyond the natural nitrogen fixation and anaerobic nitrate reduction processes.

No water quality objectives for TKN have been set.

Nitrate & Nitrite

Nitrite is present in natural waters as an intermediary in the oxidation of ammonia by autotrophic nitrophying bacteria or in the anaerobic reduction of nitrate. In either case, nitrite nitrogen concentrations rarely exceed 0.1 mg/l in natural systems. Higher concentrations usually reflect the presence of an industrial effluent which is creating rapid chemical changes

in the natural balance of nutrients.

Nitrates are natural constitutes of plants, being present in significant quantities in many vegetables and to a lesser extent in fruit. Potential sources of nitrate in the environment arise from the agricultural use of fertilizers, nitrogen fixation of micro-organisms and plants, decomposition of sewage wastes, leaching from soil and rocks etc. Nitrates are formed via the oxidation of nitrite by autotrophic nitrifying bacteria and represent the most highly oxidized form of nitrogen within the nitrogen cycle. Surface waters generally contain trace levels of nitrate ion while ground waters may contain significant concentrations due to soil leaching.

Nitrate is one of several nutrients responsible for acceleration of the natural eutrophication process in surface waters. Excessive inputs tend to promote abnormal aquatic plant growth which results in the deterioration of recreational facilities such as boating, swimming, water skiing etc. In drinking waters, excess amounts can contribute to a disease known as infant methemoglobinemia in which the oxygen carrying capacity of the blood is inhibited. The maximum acceptable level for domestic water supplies in Ontario is 10 mg/l nitrate nitrogen. Nitrate present in significant amount in water supplies used for farm animals is known to have deleterious effects.

No Agreement Objectives for nitrogen have been established.

Phosphorus

Phosphorus is a naturally occurring element that is essential to the growth of organisms. Phosphorus is found in natural waters and wastewaters as orthophosphate, condensed polyphosphates or organically bound phosphorus compounds. Both dissolved and participate inorganic and organic forms are common.

A major source of phosphorus entering the ecosystem through wastewater discharges has occurred from the widespread use of household detergents. Industries and municipalities which do not practice phosphate removal procedures can also contribute significant amounts of phosphorus to the

aquatic environment. Orthophosphate compounds and phosphorus pentoxide, common ingredients of agricultural fertilizers, are carried into natural water during storm runoffs and spring snow melts.

Although phosphorus can be the growth-limiting nutrient in natural systems, excessive quantities promote the nuisance growth of photosynthetic aquatic micro- and macro-organisms. As phosphorus occurs in nature in a variety of forms, regeneration of readily available orthophosphate from more complex inorganic or organically bound phosphate molecules may establish an algal growth and decay cycle which affects the water quality. During heavy growth periods the water column will lose clarity as well as appearing greenish in colour, while during decay periods the water quality is degraded by removal of dissolved oxygen consumed in the oxidation processes. The introduction of the phosphate removal program at sewage treatment plants has been effective in reducing the loadings of phosphate to natural waters. Salts of calcium, aluminum, or ferric iron are added during the treatment process to remove dissolved phosphate by a precipitation flocculation process.

At present scientific information is insufficient for the development of a firm objective. As an interim measure MOE has suggested that to avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period against aesthetic deterioration an objective of less than 0.01 mg/litre has also been suggested.

Agreement Objectives state that phosphorus "concentrations should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use". No criteria are suggested.

Silicate

The element silicon ranks second only to oxygen in abundance in the earth's crust and is a major constitute of silica, SiO_2, or silicates, SiO_3^{2-} and SiO_4^{4-} which exist as monomers or polymeric chains and cyclic anions. In natural waters, soluble and colloidal forms of all the polymorphs of silica may be present.

The presence of dissolved silicates along with other nutrients is essential to the growth of diatoms which incorporate silica into their skeletal structure. Silica is widely used in industry for the manufacture of glass, ceramics, abrasives and enamels. Also, silicates have been used in domestic water treatment as a coagulant and corrosion inhibitor although in high pressure water systems, failure to remove dissolved silica compounds may result in a detrimental accumulation of silica deposits. No adverse physiological effects are known at concentrations generally found in natural or treated waters.

No objectives have been suggested for concentration of silicate in water. Presence or absence of this element in a filtered sample, may however indicate cyclic changes in diatom populations.

Chlorophyll

Chlorophyll A is used as a measure of algal biomass and therefore indicates the degree of nutrient enrichment or trophic stage of a lake. Oligotrophic waters have chlorophyll A concentrations of 0-4 mg/m^3, eutrophic waters 10-100 mg/m^3, and mesotrophic waters are between 4 and 10 milligrams chlorophyll A per cubic metre of water (EPA 1973).

"Corrected" chlorophyll A values are used for this measurement as it does not contain phaeophytins. Large differences between corrected and uncorrected chlorophyll A values may indicate algal populations of dead and decaying organisms.

Dissolved Material

Conductivity

Conductivity is a measure of the capacity of a water to convey an electric current. This capacity is related to the total concentration of ionized substances in the water and is temperature dependent. The test is so precise and accurate that conductivity is frequently preferred to a dissolved solids test as an indicator of the dissolved solids content of a routine river or water sample.

Most raw and finished waters in Canada and the United States have conductivities in the range of 50 - 500 micromhos/cm with highly mineralized waters ranging up above 1000 micromhos/cm.

Conductivity (umhos/cm) can be converted to total dissolved solids (mg/l) by multiplying by 0.67 (EPA 1973). Total dissolved solids provides an indication of the productivity of the water. High concentration of ions can produce osmotic stress in aquatic organisms. The levels of total dissolved solids associated with freshwater aquatic life protection are less than 200 mg/l for "good" protection of aquatic life, between 200 and 500 mg/l for "fair" protection, and above 500 mg/l for "poor" protection Bennett (1971). Agreement Objectives criteria for dissolved solids is 200 mg/l.

Chloride

Deicing salt is the largest single source of chlorides watercourses in Ontario (Ralston and Hamilton 1978). Concentrations range from 10-20 mg/litre for rural areas, 30 - 70 mg/l for suburban areas, and greater than 100 mg/l for urban watercourses.

The MOE objective for chloride in public surface water supplies is 250 mg/l. Some industries may require lower concentrations to prevent corrosion. Irrigation chloride levels have been set at a maximum of 150 mg/l to prevent crop damage. Specialty crops may require lower levels. No criteria have been formulated for the protection of aquatic life. Rapid fluctuations in chloride levels may be more important than absolute concentrations.

No Agreement Objectives for chloride have been established.

Oxygen Saturation

Dissolved oxygen is a measure of the soluble oxygen available to the aquatic community. Reduction of dissolved oxygen levels results in a diminished level of productivity for the water body and increased stress on aquatic organisms.

Provincial objectives for dissolved oxygen state:

At no time should dissolved oxygen concentrations be less than the values specified below:

	Dissolved Oxygen Concentration			
	Cold Water Biota		Warm Water Biota	
Temperature C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4

In situations where additional physical and/or chemical stresses are present these minimum levels may prove inadequate and more stringent objectives may be necessary.

In some hypolimnetic waters, dissolved oxygen is naturally lower than the above-specified concentrations. Such a condition should not be altered by adding oxygen demanding materials causing a depletion of dissolved oxygen.

The Agreement Objectives state: in the Connecting Channels and in the upper waters of the Lakes, the dissolved oxygen level should be not less than 6.0 milligrams per litre at any time; in hypolimnetic waters, it should be not less than necessary for the support of fishlife, particularly cold water species.

Transparency

Turbidity and Secchi Disc

Turbidity measures the ability of light to pass through water. Light

penetration is important to the photosynthetic capabilities of aquatic plants. Consequently the Provincial objective for turbidity states: "suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10 percent. Previous MOE objectives were that turbidity should not exceed 25 JTU in warm lakes or 10 JTU in oligotrophic lakes. Note: Nephelometric turbidity units (NTU) are equivalent to Jackson turbidity units (JTU).

No Agreement Objective criteria are established.

Metals

Iron

Iron is present in high concentrations in most rocks and soils, as well as in ore deposits. Input to the Great Lakes originates with weathering of rocks and soils; mining and processing of iron ores; steel making; metal fabricating; burning of fossil fuels; corrosion or iron or steel products in use; and corrosion of iron or steel products in junkyards, dumps and stream beds.

Total concentrations of iron in the Great Lakes average less than 120 ug/L. Inshore, iron in filtered samples average less than 50 ug/L in water intakes and concentrations never exceeded 200 ug/L. In waters adjacent to known sources of iron in the Great Lakes, concentrations may be much higher. For example, in Hamilton Bay in 1972, total iron concentrations were always greater than 200 ug/L, and most samples were between 300 and 700 ug/L. Some samples were recorded as high as 3,700 ug/L. (MOE 1979).

Due to its known toxicity to aquatic organisms a concentration of 0.3 mg/litre of total iron has been set as the Provincial objective. The international criteria for iron is also set at 0.3 mg/litre, however, this concentration was based on a filtered sample.

Microbiology

Heterotrophic Bacteria

Aerobic heterotrophic bacteria are found in surface and waste waters. Varying nutrient levels will affect the number and types of viable bacteria present. Heterotrophic bacteria are thus an indication of nutrient enrichment and the trophic states of the water body which can effect general aesthetics, bathing and aquatic life.

A relationship between the geometric mean density of heterotrophic bacteria per 100 ml and the mean summer chlorophyll A concentration (ug/l) has been determined for recreational lakes in Muskoka (Hendry, 1977). This relationship is log heterotroph = 4.46 + 1.80 log chlorophyll A. Substituting the values of chlorophyll A for oligotrophic, mesotrophic and eutrophic conditions (EPA 1973) criteria for heterotrophic bacteria were determined as less than 3,500 ml for mesotrophic waters, and greater than 18,000 ml for eutrophic waters.

Heterotrophic bacteria are used only as an indicator of water quality. No objectives have been set.

Total Coliform

Total coliforms are also an indicator of water quality. Ontario MOE guidelines consider water quality impaired when the total coliform geometric mean density for a series of water samples exceeds 1000 per 100 ml. Agreement Objectives are the same.

Fecal Coliform

Fecal coliforms indicate the presence of sewage or fecal matter and therefore potential pathogens. Provincial water quality objectives state a potential health hazard exists if the fecal coliform geometric mean density for a series of water samples exceeds 100 per 100 ml. Agreement Objectives set a limit of 200 fecal coliforms per 100 ml for five samples taken over a 30 day period.

Fecal Streptococci

Objectives have not been set for number of fecal streptococci in water samples. They are however, a useful water quality indicator when used in conjunction with the fecal coliforms as an indication of the nature of the potential fecal source. If the ratio of the geometric mean densities of the fecal coliforms to fecal streptococci at the point of discharge exceeds 4, the source of the discharge is likely to be human in origin. A ratio of less than 0.7 suggests that the source is probably of non-human origin. Ratios between these values are difficult to interpret and may indeed be mixtures. For reliable ratio data, the fecal coliform density should approach or exceed 100 per 100 ml. The ratio must be applied carefully as numerous environmental factors will influence the densities of both these organisms.

Pseudomonas

No standards exist for other bacteria responsible for enteric disorders, or eye, ear, nose throat and skin infections such as Pseudomonas aeruginosa. Agreement Objectives state that such organisms should be "substantially free" from such organisms.

This information is summarized on Table 1.

TABLE 1

WATER QUALITY PARAMETERS AND OBJECTIVES

PARAMETER MEASURED	PROVINCIAL OBJECTIVE	AGREEMENT OBJECTIVE	SIGNIFICANCE	REFERENCE
<u>Nutrients & Productivity</u>				
Ammonia (un-ionized)	0.02 - aquatic life	0.020 - aquatic life 0.50 - public water		
TKN	none	none	0.1 - 0.5 mg/l - clean 50 mg/l - waste water	MOE 1972
Nitrite	none	none	0.1 mg/l - background	
Nitrate	10 mg/l - public water	none		
Total Phosphorus	none	none	0.01 mg/l - aesthetics 0.02 mg/l - algae growth	Provincial Water Quality Objectives
Silicate	none	none		
Chlorophyll A	none	none	0 - 4 µg/l - oligotrophic 4 - 10 µg/l - mesotrophic 10 - 100 µg/l - eutrophic	EPA 1973
<u>Dissolved Material</u>				
Conductivity µmhos	none	300	50 - 500 - background 300 - good - aquatic life 300 - 750 - fair - aquatic life >750 - poor - aquatic life	Bennet 1971
Chloride	250 mg/l - public water 150 mg/l - irrigation	none	10 - 20 mg/l - rural 30 - 70 mg/l - suburban >100 - urban	MOE Ralston & Hamilton 1978
Oxygen	4 - 8 mg/l	6.0 mg/l		
<u>Transparency</u>				
Turbidity FTU	Δsecchi disc <10%	none	<10 - oligotrophic 10 - 25 - mesotrophic >25 - eutrophic	MOE Objectives
<u>Metals</u>				
Iron	0.3 mg/l	0.3 mg/l		
<u>Microbiology</u>				
Heterotrophic bacteria	none	none	<3500/ml - oligotrophic 3500 - 18,000/ml - mesotrophic >18,000/ml - eutrophic	EPA 1973
Total coliform	1000/100 ml	1000/100 ml		
Fecal coliform	100/100 ml	200/100 ml		
Fecal streptococci	none	none	- ratio to fecal coliform indicates source	Dutka, B.J. 1973
Pseudomonas	none	absent	- indicates disease pathogen	

3.0 RONDEAU HARBOUR

3.0 RONDEAU HARBOUR

3.1 Introduction

Rondeau Provincial Park occupies approximately 4900 hectares of the spitt which defines Rondeau Harbour. This park is heavily utilized for angling, boating, nature observation, swimming, waterskiing, waterfowl hunting, ice fishing and ice boating (MNR 1981). The sheltered nature of this large bay makes it an ideal centre for these diverse recreational activities. The shallow, marsh shoreline and fluctuating water levels limit shore fishing. High bacterial counts and turbidity reduce the desirability of body contact opportunities in this area.

Excerpts from a Ministry of Natural Resources draft report entitled Rondeau Bay; Recreation and Access Study, 1978, are presented in Appendix 1. This report elaborates on recreational opportunities and utilization rate of Rondeau Harbour.

The west side of the bay is mainly in private ownership. The Lower Thames Valley Conservation Authority own some Marsh property in the village of Shrewsbury. This Authority reports that there is no industry in the area but farmland field erosion has caused a deterioration in water quality by the discharge of soil and fertilizers into the bay. Appendix 2 contains this Authority's Wetland Acquisition Study on Rondeau Bay. Water level fluctuations are a major factor determining the nature of the wetland habitat.

Approximately seven creeks drain into Rondeau Harbour. No large rivers discharge into this bay. There is a small commercial fishery based at Erieau and coal is shipped through this port.

3.2 Historical Water Chemistry

Water quality within Rondeau Harbour has been noted to be high in bacterial counts and turbidity (MNR 1981). Data for station 839 (Figure 1) were available for

1975. This station is located at the entrance to the harbour and therefore likely mixes with the open waters of Lake Erie. All parameters measured indicated fair to good water quality except secchi depth, bacteria, chlorophyll and Total P. Secchi depth averaged only 0.8 metres which indicates poor light penetration. Total P values obtained for 1975 and 1979 show substantial increases (100%). Both 1975 and 1979 values were above MOE objectives for aesthetic deterioration and algae growth of 0.01 and 0.02 mg/l. Total coliform bacteria exceeded Provincial criteria on one occasion and the number of heterotrophic bacteria indicate mesotrophic conditions. The finding of 16 1975 pseudomonas per 100 ml on September 6th suggests that water contact recreation may expose users to some health risk. More data is required.

3.3 Water Chemistry

Three stations were sampled on the 20 - 22 April, 20 - 21 August and 28 - 29 November of 1979. Station locations are shown on Figure 1. The data are presented in Table 2.

3.3.1 Nutrients & Productivity

Ammonia levels ranged from 0.005 to 0.080 mg/l throughout the study. Estimating the pH as 8.3 indicates that the criterion for un-ionized ammonia of 0.02 was never exceeded.

Total Kjeldahl Nitrogen values ranged from 0.29 to 0.567 mg/l during this study. These levels are moderate to high indicating a mesotrophic system. No differences between stations were evident.

Nitrate & Nitrite nitrogen values were somewhat elevated, ranging from 0.01 to 1.15 mg/litre. No objectives were exceeded at any time.

TABLE 2

RONDEAU HARBOUR: 1979 WATER QUALITY DATA

STATION #	#1242			#1243			#839		
MONTH	APRIL	AUGUST	OCTOBER	APRIL	AUGUST	OCTOBER	APRIL	AUGUST	OCTOBER
Nutrients & Productivity									
Ammonia	0.022±0.012 0.015-0.035	0.013±0.010 0.005-0.025	0.013±0.003 0.010-0.015	0.055±0.022 0.040-0.080	0.013±0.010 0.005-0.025	0.017±0.003 0.015-0.020	0.038±0.003 0.035-0.040	0.025±0.022 0.010-0.050	0.015±0.005 0.010-0.020
Total Kjeldahl Nitrogen	0.390±0.106 0.310-0.510	0.360±0.044 0.310-0.390	0.460±0.0 0.460-0.460	0.557±0.071 0.480-0.620	0.360±0.061 0.290-0.400	0.403±0.057 0.340-0.450	0.510±0.056 0.450-0.560	0.430±0.079 0.340-0.490	0.380±0.076 0.300-0.450
Nitrate & Nitrite	0.593±0.344 0.370-0.990	0.107±0.040 0.060-0.130	0.017±0.006 0.010-0.020	1.133±0.015 1.120-1.150	0.087±0.055 0.050-0.150	0.017±0.006 0.010-0.020	1.003±0.087 0.930-1.100	0.120±0.069 0.040-0.160	0.017±0.006 0.010-0.020
Total Phosphorus	0.052±0.021 0.032-0.074	0.035±0.013 0.020-0.043	0.051±0.003 0.048-0.053	0.104±0.045 0.071-0.155	0.032±0.012 0.019-0.041	0.054±0.011 0.043-0.065	0.078±0.018 0.062-0.097	0.027±0.011 0.019-0.040	0.046±0.005 0.040-0.049
Total Reactive Phosphorus	0.009±0.003 0.006-0.012	0.005±0.001 0.004-0.005	0.006±0.002 0.004-0.008	0.017±0.005 0.012-0.021	0.004±0.001 0.003-0.005	0.006±0.001 0.005-0.006	0.022±0.008 0.016-0.031	0.006±0.002 0.004-0.008	0.005±0.001 0.004-0.005
Silicate	0.11±0.03 0.08-0.14	0.33±0.10 0.22-0.42	0.05±0.01 0.04-0.06	0.15±0.03 0.12-0.18	0.39±0.05 0.34-0.44	0.06±0.02 0.04-0.08	0.13±0.06 0.06-0.18	0.33±0.06 0.26-0.36	0.06±0.02 0.04-0.08
Chlorophyll A	5.83±0.93 4.80-6.60	7.93±1.76 6.10-9.60	16.77±1.76 15.10-18.60	5.97±0.31 5.70-63.0	8.33±2.30 5.80-10.30	17.30±1.25 16.00-18.50	7.07±0.80 6.30-7.90	8.07±2.49 6.20-10.90	16.07±0.71 15.30-16.70
Corrected Chlorophyll A	4.40±0.95 3.80-5.50	6.60±1.32 5.10-7.60	8.93±5.35 5.60-15.10	4.33±1.18 3.60-5.70	6.73±1.75 5.00-	14.37±1.27 12.90-15.20	4.87±1.25 4.00-6.30	6.47±1.25 5.20-7.70	12.33±1.53 10.70-
Dissolved Constituents									
Conductivity µmhos	294±3 292-297	292±6 285-295	297±3 294-300	296±3 292-298	296±6 290-300	295±3 291-297	296±1 296-297	292±7 287-300	296±5 293-302
Chloride	18.50±0.0 18.50-18.50	18.67±0.29 18.5-19.00	18.50±0.0 18.50-18.50	18.17±0.29 18.00-18.50	18.83±0.76 18.00-19.50	18.50±0.0 18.50-18.50	18.33±0.29 18.00-18.50	18.50±0.50 18.00-19.00	18.67±0.29 18.50-19.00
Oxygen (% saturation)	93.3 92-94	109 93-127	92 91-93	90 87-94	105 86-115	90 88-93	94.3 92-96	105.7 87-119	89 88-90
Transparency									
Turbidity FTU	24.33±8.74 17.00-34.00	4.07±3.38 1.20-7.80	19.00±3.61 16.00-23.00	38.00±5.57 32.00-43.00	5.47±3.02 2.00-7.50	21.33±4.51 17.00-26.00	35.67±7.37 30.00-44.00	4.40±3.98 2.00-9.00	19.00±1.00 18.00-20.00
Secchi Disc meters	0.20±0.12 0.10-0.30	1.50±0.32 1.10-1.80	0.20±0.0 0.20-0.20	0.15±0.06 0.10-0.20	0.65±0.17 0.50-0.80	0.27±0.05 0.20-0.30	0.15±0.06 0.10-0.20	1.23±0.54 0.60-1.80	0.20±0.0 0.20-0.20
Metals									
Iron		0.24±0.21 0.07-0.48	1.35±0.15 1.24-1.52		0.30±0.17 0.11-0.43	1.60±0.38 1.20-1.96		0.25±0.22 0.12-0.50	1.35±0.13 1.20-1.43
Microbiology									
Heterotrophic bacteria	7687 3950-11500	2646 2000-3500	7687 3950-11500	11635 7500-17500	2739 1500-5000	11635 7500-17500	9526 6500-11400	3500 3500-3500	9526 6500-14000
Total Coliform/100 ml	18 8-28	294 144-600	18 8-28	36 16-90	224 224-224	36 16-90	34 16-80	147 104-208	34 16-80
Fecal Coliform/100 ml	4 4-4	4 4-4	7 4-12	5 4-10	35 20-66	16 8-32	5 4-10	10 8-12	17 16-20
Fecal Streptococci/100ml	8 4-28	4 4-4	8 4-16	18 10-24	8 4-16	4 4-4	35 24-44	8 4-16	7 4-
Pseudomonas/100 ml	4 4-4	4 4-4	4 4-4	4 4-4	4 4-4	4 4-4	4 4-4	4 4-4	4 4-4

Key: Mean±SD
Min-Max

Total phosphorus average always exceeded the 0.02 mg/l objective for limiting the growth of algae. Data are insufficient to enable statistical comparisons, however, Station 839 generally exhibited lower phosphorus concentrations than the two inner stations. Figure 2 shows ambient levels remaining the same at Station 1174. However, Total P values for all stations are in excess of the objective for aesthetic deterioration of 10 mg/l.

Silicate values reached a peak in August at all stations indicating a decline in diatom populations during the warm summer months.

Chlorophyll A average concentrations ranged from 5.83 to 17.03 indicating mesotrophic conditions tending towards eutrophy. This is substantiated by the data which shows values increasing steadily to peak in the fall (Figure 3).

3.3.2 Dissolved Material

Conductivity values were constant at all stations and on all dates sampled at approximately 295 umhos. This level is well within acceptable limits and indicates a good level of protection for aquatic life.

Chloride levels were also constant throughout this study at approximately 18.5 mg/l. This level and lack of fluctuations indicates that there are no major point sources of chlorides to this system.

3.3.3 Oxygen Saturation

Oxygen saturation was consistently above levels necessary for the protection of aquatic life. The lowest value recorded was 86% saturation. Level of saturation above 100% indicate the presence of photosynthetic organisms. Levels of 105% saturation are not uncommon for bodies of water supporting algae populations.

3.3.4 Transparency

Turbidity levels were highest in April and October. This could reflect sediment import from watershed areas during peak flows in area tributaries, however, more data are needed to confirm this hypothesis.

Secchi disc depth values exhibit the same relationship as turbidity values with clearer water being noted in August. It is interesting to note that secchi depth and turbidity values are independent of chlorophyll concentrations which show an increase throughout the study period. Clarity of the water therefore appears more dependent on the physical properties than productivity within harbour.

3.3.5 Metals

Iron levels were very high especially during October when they reached a maximum of 1.96 mg/litre. Since the water of Rondeau harbour is well oxygenated most of this iron is likely in an insoluble non-ionic form and hence non-toxic. These levels are well above objectives established by both Provincial and International agencies and its source should be determined.

3.4 Microbiology

Total Heterotrophic Bacteria levels ranged from a mean of 2646 to 11635 bacteria per ml. These values indicate a slightly mesotrophic system.

Total Coliform values never exceeded 600 cells per 100 ml, and therefore met the objectives of 1000 per 100 ml.

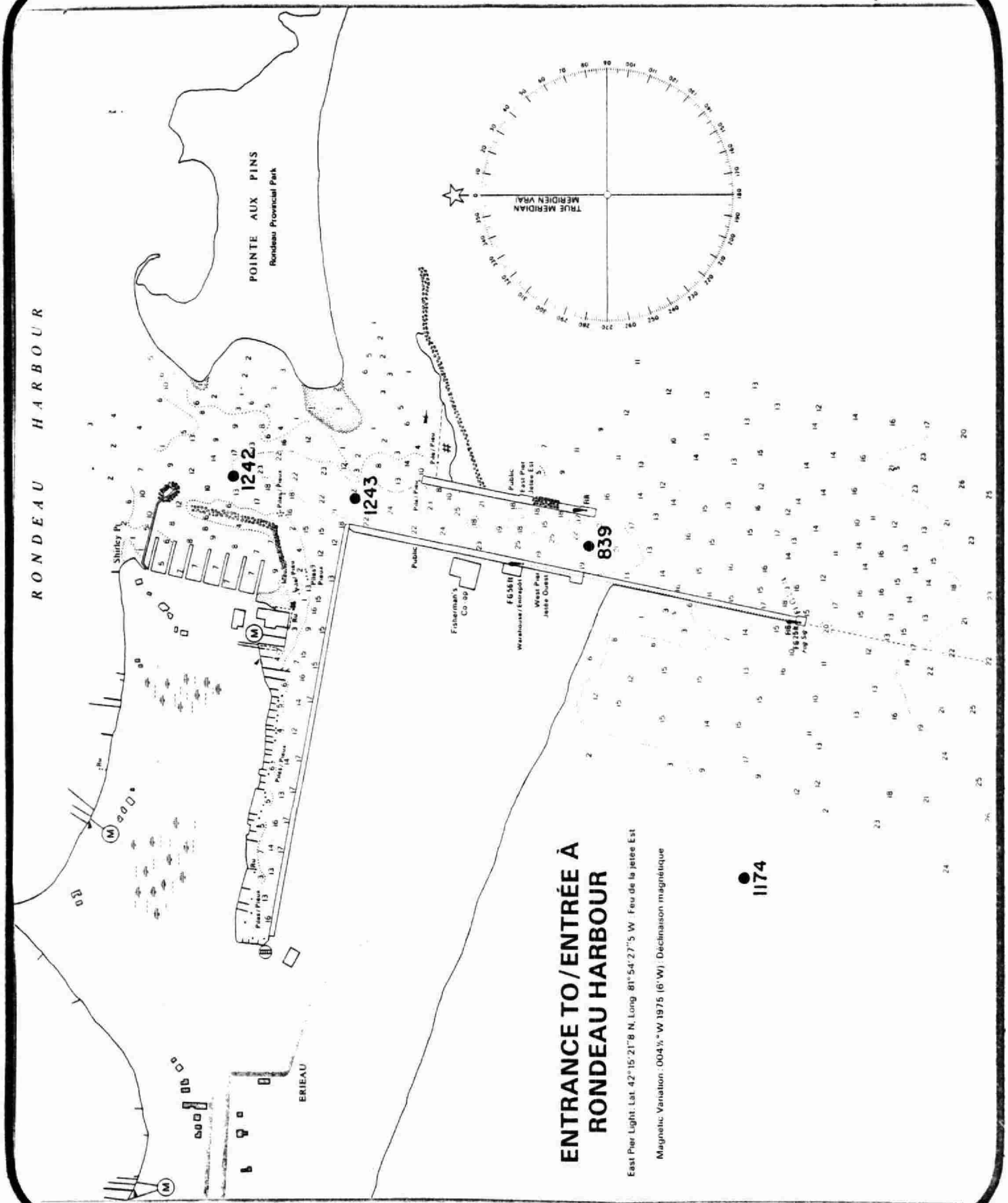
Fecal Coliform and Fecal Streptococci numbers also did not exceed Provincial and International objectives.

Pseudomonas levels, while not absent, were very low indicating little health risk from body contact recreation.

3.5 Summary

The entrance to Rondeau Harbour was sampled in April, August and October 1979. The data indicate that the water quality is fair to good for aquatic life and recreation. Water clarity was found to be poor, especially in the spring and fall. Contrary to historical data, bacterial contamination was not found to be a problem at those stations sampled. Reasons for this apparent improvement in water quality were not determined. Historically, phosphorus levels were found to have increased substantially since 1975, indicating more eutrophic conditions. High concentrations of iron were found which could not be explained. A study of sources for these high values is recommended.

Based on chlorophyll, phosphorus, turbidity and heterotrophic bacteria levels, the Rondeau Harbour stations were found to indicate mesotrophic conditions.

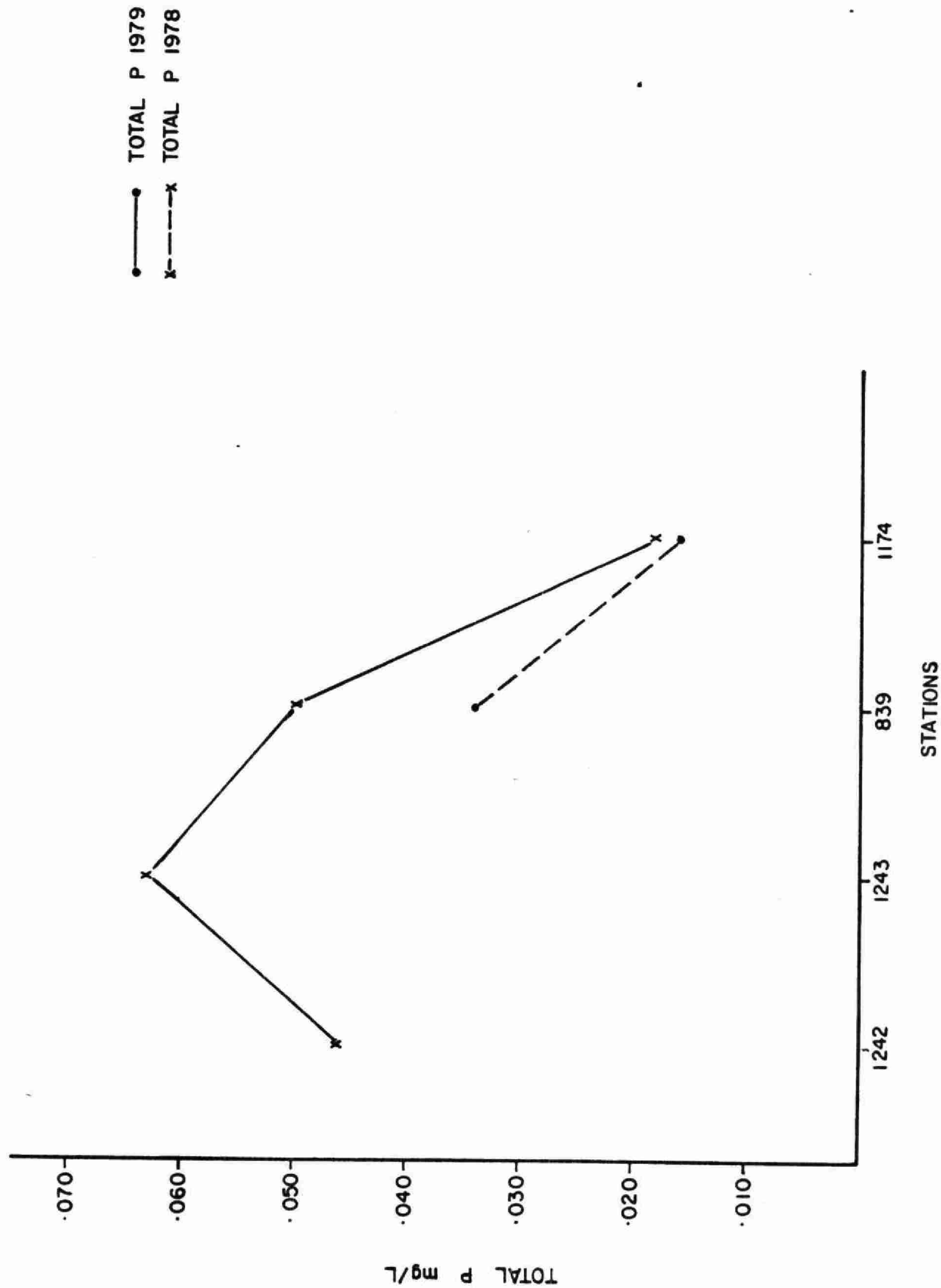


RONDEAU HARBOUR

WATER QUALITY STATIONS 1979

SCALE 1: 6,720

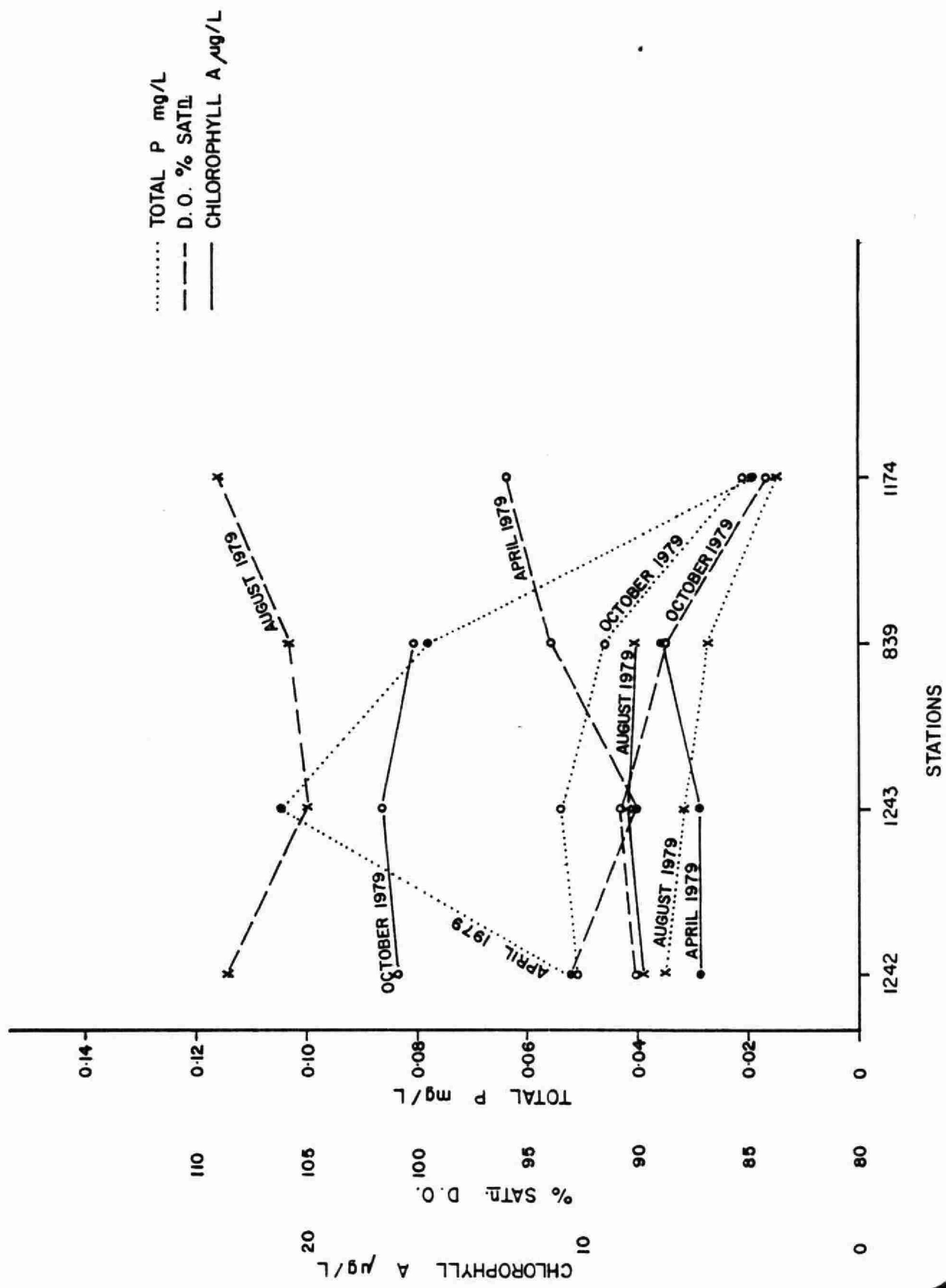
FIGURE I



RONDEAU HARBOUR

COMPARISONS OF 1978 & 1979 TOTAL P VALUES

FIGURE 2



RONDEAU HARBOUR

1979 CRUISE DATA FOR % SATn. D.O. & TOTAL P

FIGURE 3

4.0 PORT STANLEY

4.0 PORT STANLEY

4.1 Introduction

Port Stanley is an active shipping centre on Lake Erie serving some of the transportation needs of the City of St. Thomas. In addition to harbouring a commercial fishing fleet, Port Stanely has an oil terminal and coal stockpile controlled by Ultramahr, a co-operative phosphate fertilizer storage area, two grain elevators, and a salt and a caustic soda storage area.

The two main communities in the Kettle Creek watershed are Port Stanley and St. Thomas. Port Stanley has a conventional 0.323 MIGD (million Imperial gallons/day) sewage lagoon which has seasonal phosphorus removal prior to discharge to Kettle Creek. St. Thomas has a conventional secondary sewage treatment plant with phosphorus removal. It discharges 3.75 MIGD to Kettle Creek. Intense farming in the Kettle Creek watershed has resulted in high sediment import to this creek.

For ease of discussion this port has been divided into inner and outer harbour stations. Station 776 to 779 were considered inner harbour stations and stations 756 to 1082 were considered outer harbour stations. This distinction is not meant to imply that a mixing zone has been defined.

4.2 Historical Water Chemistry

In addition to 1979 data reported here, cruise data for 1975 was also reviewed. Only one sample was taken at each station making quantitative comparisons difficult.

Data for ammonia, nitrate and nitrite, total phosphorus, total reactive phosphorus, conductivity, chloride, oxygen saturation, turbidity and total coliform were available for comparison between 1975 and 1979. In 1975 no differences between inner and outer harbour stations were evident. In 1979 the inner harbour stations exhibited poorer water quality for all parameters, than the outer harbour stations. This phenomenon is shown graphically on Figure 2 for total phosphorus concentrations by station. In

addition, concentrations of phosphorus in Kettle Creek upstream of the harbour are shown on this figure. This shows that between 1972 and 1980 the concentration of phosphorus in the creek increased approximately four hundred percent. Similar relationships exist for concentrations of nitrogen, chlorophyll A and coliforms (Figures 4 and 5).

4.3 Water Chemistry

As shown on Figure 2 stations 779 to 776 tend to exhibit greater water quality degradation than outer harbour stations. Station 1082 was found to reflect conditions within Lake Erie which are considered background.

Data for eight stations sampled are lumped into inner and outer harbour areas. Station locations are shown on Figure 6. The data is presented in Table 3. Sampling was conducted on 21 - 23 April, 21 - 23 August and October 29 to November 3.

4.3.1 Nutrients and Productivity

Ammonia, as with all parameters, was more concentrated at inner harbour stations. Assuming a pH of approximately 8, no values were found to exceed objectives. The maximum concentration found was 0.325 mg/l filtered ammonia or approximately 0.009 mg/l un-ionized ammonia.

Total Kjeldahl Nitrogen average values were within the 0.1 to 0.5 mg/l "clean" range at outer harbour stations and above it at inner stations. Concentrations ranged from 0.260 to 1.120 mg/l at inner stations and 0.190 to 0.630 at outer stations, indicating that there are sources of nitrogen affecting the harbour water quality. These sources are upstream of the harbour.

Nitrate and Nitrite concentrations were approximately one order of magnitude higher at the inner harbour stations. Two values of 4.4 mg/litre were reported at Stations 778 and 779. Sources of this nitrogen therefore appear to originate upstream of the harbour. This value is approximately one half of the 10 mg/litre objective for

TABLE 3

PORT STANLEY: 1979 WATER QUALITY DATA

	INNER HARBOUR			OUTER HARBOUR		
	APRIL	AUGUST	OCTOBER	APRIL	AUGUST	OCTOBER
Nutrients & Productivity						
Ammonia	0.182 ± 0.0420 0.070 - 0.235	0.0325 ± 0.0492 0.010 - 0.075	0.1648 ± 0.0722 0.040 - 0.325	0.0488 ± 0.0385 0.015 - 0.130	0.0103 ± 0.018 0.005 - 0.025	0.0225 ± 0.0060 0.010 - 0.045
Total Kjeldahl N	0.819 ± 0.0917 0.450 - 0.980	0.6335 ± 0.278 0.260 - 1.120	0.5668 ± 0.0403 0.310 - 1.010	0.4235 ± 0.0802 0.300 - 0.630	0.24 ± 0.034 0.190 - 0.280	0.2983 ± 0.0313 0.250 - 0.350
Nitrate & Nitrite	3.37 ± 0.733 1.400 - 4.400	0.7993 ± 0.3598 0.100 - 1.880	0.7525 ± 0.5591 0.190 - 1.850	0.7973 ± 0.5667 0.240 - 2.20	0.076 ± 0.0335 0.040 - 0.090	0.0733 ± 0.033 0.030 - 0.180
Total Phosphorus	0.1325 ± 0.037 0.060 - 0.185	0.1545 ± 0.052 0.028 - 0.365	0.113 ± 0.0495 0.059 - 0.230	0.0485 ± 0.0107 0.029 - 0.077	0.0158 ± 0.0061	0.0543 ± 0.0148 0.030 - 0.085
Total Reactive P	0.0325 ± 0.0140 0.017 - 0.050	0.052 ± 0.0752 0.005 - 0.158	0.035 ± 0.0116 0.011 - 0.065	0.013 ± 0.0073 0.004 - 0.021	0.003 ± 0.0018 0.002 - 0.008	0.00725 ± 0.0013 0.005 - 0.013
Silicate	2.145 ± 0.655 0.74 - 2.66	0.4625 ± 0.1515 0.24 - 0.92	0.87 ± 0.4131 0.48 - 1.74	0.5075 ± 0.3282 0.04 - 1.28	0.213 ± 0.028 0.18 - 0.24	0.25 ± 0.044 0.12 - 0.42
Chlorophyll A	7.195 ± 4.357 2.20 - 15.10	22.733 ± 9.313 4.30 - 61.00	7.335 ± 1.728 5.30 - 10.40	4.208 ± 0.941 2.80 - 4.80	4.298 ± 1.548 2.30 - 7.40	7.673 ± 1.890 5.70 - 12.40
Corrected Chlorophyll A	2.964 ± 1.868 0.20 - 6.00	22.448 ± 9.318 4.20 - 61.00	4.2525 ± 2.089 1.00 - 7.00	2.1425 ± 1.800 0.70 - 5.10	3.905 ± 1.303 2.60 - 5.90	5.138 ± 2.192 2.90 - 9.60
Dissolved Material						
Conductivity	527.5 ± 46.373 352 - 590	373.75 ± 33.83 296 - 477	381 ± 69.318 307 - 525	334.5 ± 28.342 294 - 439	293.5 ± 3.808 289 - 305	294.25 ± 2.915 289 - 960
Chloride	29.875 ± 2.475 21.50 - 33.50	22.17 ± 3.314 20.00 - 37.50	27.46 ± 5.512 20.50 - 39.00	20.915 ± 1.363 19.00 - 26.50	19.625 ± 0.5398 19.00 - 21.00	18.61 ± 0.459 18.00 - 20.00
Oxygen Saturation	89.175 84 - 99	96.25 84 - 122	82.93 75 - 90	98.18 90 - 102	87.35 79 - 91	89.425 86 - 92
Transparency						
Turbidity	29.918 ± 7.776 17.00 - 43.00	17.383 ± 9.793 7.70 - 39.00	49.33 ± 8.623 39.00 - 71.00	14.6 ± 6.594 1.00 - 27.00	6.21 ± 3.349 2.900 - 18.00	41.168 ± 18.41 10.00 - 84.00
Secchi Disc	0.225 ± 0.043 0.20 - 0.30	0.455 ± 0.212 0.20 - 0.90	0.13 ± 0.05 0.10 - 0.20	0.4925 ± 0.1938 0.20 - 1.00	1.335 ± 0.2438 0.800 - 2.00	0.1875 ± 0.051 0.10 - 0.60
Metals						
Iron	1.52 ± 0.240 1.00 - 2.06	0.755 ± 0.3843 0.27 - 1.46	2.155 ± 0.522 1.66 - 3.30	0.6825 ± 0.226 0.33 - 1.36	0.23 ± 0.1513 0.11 - 0.73	2.178 ± 0.9447 0.48 - 4.20
Microbiology						
Heterotrophic bacteria	88,909.37 45,500-255,000	122,744.77 7,000-666,000	88,909.37 45,000-255,000	3,827.42 650-60,000	14,640.37 1,000-45,500	3,827.42 650-60,000
Total Coliform	1320.89 52 - 28,000	542.90 8 - 5900	1320.89 52 - 28,000	45.248	13.9398 4 - 700	45.248 4 - 2600
Fecal Coliform	454.76 290 - 690	42.07 4 - 160	173.12 32 - 600	358 250 - 512	7.44 4 - 560	17.748 4 - 360
Fecal Streptuccoi	68.21 36 - 116	107.16 8 - 428	195.16 36 - 600	55 40 - 76	7.113 4	13.148 4 - 172
Pseudomonas	6.982 4 - 76	4.23 4 - 8	6.982 4 - 76	4 4 - 4	4 4 - 4	4 4 - 4

Key: Mean±SD

public water supplies.

Total Phosphorus (Figure 7) has increased greatly at upstream stations since 1972. Water from the harbour appears to be diluted rapidly as concentrations of phosphorus were near background at stations outside of the harbour. It should also be noted that both inner and outer harbour stations had concentrations of phosphorus in excess of levels known to promote the growth of algae (Figure 8). On all cruises, phosphorus concentrations were higher inside the harbour, indicating a watershed source for this nutrient.

Silicate values decreased at all stations between April and August, which indicates growth in the diatom community.

Chlorophyll A values indicate that all stations are mesotrophic with a tendency to eutrophy at inner harbour stations. It is also interesting to note that at inner harbour stations during peak phytoplankton concentrations the corrected chlorophyll A concentrations were very similar to uncorrected values. This is indicative of a very healthy phytoplankton population. The chlorophyll A counts show significant increases from 1975-79, showing the influence of high Total P values (Figure 4).

4.3.2 Dissolved Material

Conductivity values were near the Agreement Objective of 300 umhos outside of the harbour and considerably above it inside. Concentrations within the harbour indicate only a "fair" level of protection for aquatic life.

Chloride levels remained relatively consistent at each station although inner harbour values were higher than outer harbour areas. This data indicates no substantial degradation of water quality due to chlorides. Sources of ions responsible for the high conductivity values do not appear to be related to the use of salt within the watershed.

4.3.3 Oxygen Saturation

Oxygen saturation was adequate for aquatic life at all stations sampled. Since only surface water quality samples were taken, the significance of these values decreases. Due to the high nutrient values and chlorophyll concentrations already reported, lower and higher oxygen saturation values would be predicted deeper in the water column.

4.3.4 Transparency

Turbidity values ranged from 7 to 71 FTU at inner harbour stations and from 1 to 84 FTU at outside stations. On the average inner harbour stations had higher values indicating mesotrophic to eutrophic conditions. Outer harbour stations fluctuated more but were generally indicative of mesotrophic conditions.

Secchi disc depth also fluctuated more at outer harbour stations. The greatest depth reported was 0.9 metres at inner and 2.0 metres at outer harbour stations. Generally, these data indicate poor water quality conditions, although it is worse inside the harbour.

4.3.5 Metals

Iron concentrations were consistently above both Provincial and Agreement Objectives of 0.3 mg/l, in both parts of the harbour. MOE (1979) note that Great Lakes iron concentrations average less than 0.12 mg/l with Hamilton Harbour values of between 0.3 and 0.7 mg/l representing "polluted" conditions. High iron values (4.2 mg/l) in Port Stanley and Lake Erie cannot be fully explained with available data. However, a contributing factor may be Kettle Creek, which has iron levels recorded as high as 14.0 mg/l (Sampling point: first bridge above Port Stanley 29/3/77 and 2/3/78).

4.4 Microbiology

Heterotrophic bacteria were quite abundant, especially at inner harbour stations where concentrations as high as 666,000 per 100 ml were found. On the basis of heterotrophs inner harbour waters were determined to be eutrophic and outer harbour waters mesotrophic.

Total coliform levels frequently exceeded Provincial and Agreement Objectives within the harbour and occasionally exceeded them at outer harbour stations.

Fecal coliform objectives were exceeded at all stations in April and again at inner harbour stations in October. Inner harbour stations again showed greater impairment of water quality. Figure 5 shows that a potential health hazard now exists with Fecal coliform counts in excess of 100 per 100 ml, which is the MOE objective, at all stations in the inner harbour for 1979. 1975 figures complied with objectives with the exception of Station 779.

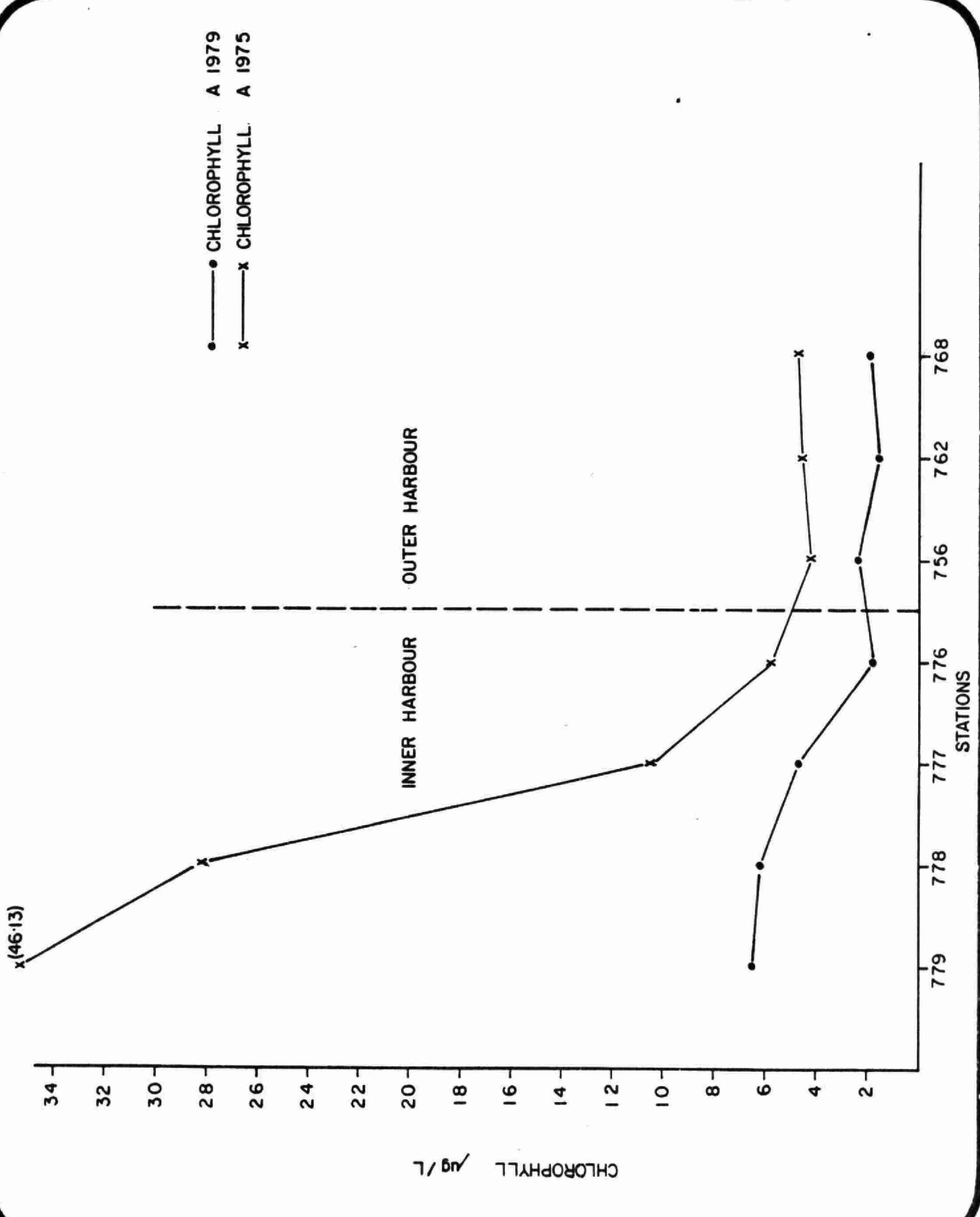
The fecal coliform to fecal streptococci (FC/FS) ratio exceeded 4 at inner harbour stations in April and October. This indicates the presence of human sewage at inner harbour stations.

Pseudomonas values were also higher at inner harbour stations indicating poor water quality for water contact recreation.

4.5 Summary

Water quality within Port Stanley harbour was found to be impaired, as determined by all parameters examined except oxygen saturation. Nutrients were very high, and this was reflected in high concentration of chlorophyll. Turbidity, Secchi disc and microbiology considerations all indicate that water contact recreation potential is severely impaired within the harbour. Historical data indicate a deterioration of water quality over the period of record.

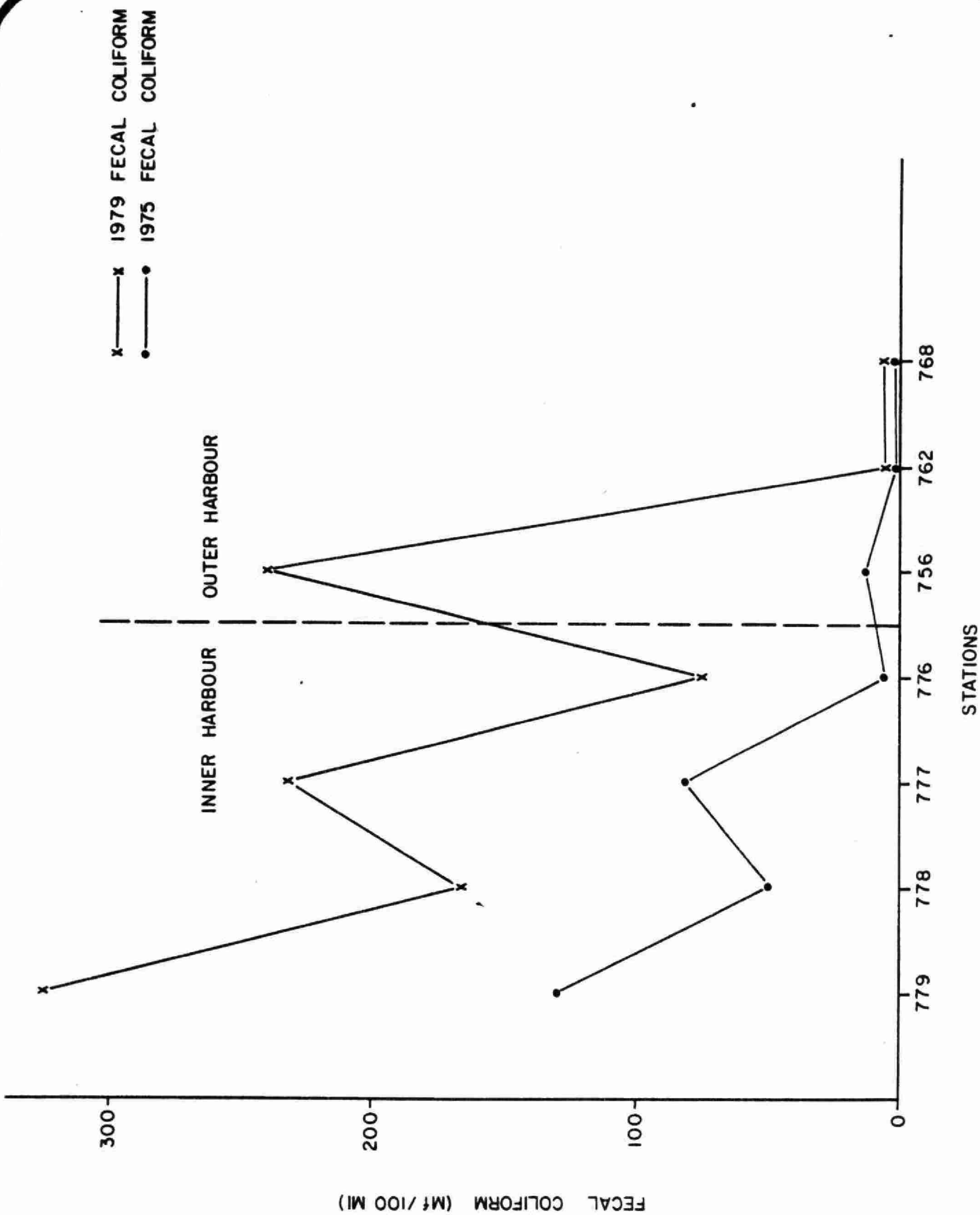
Upon leaving the harbour, water quality improves greatly, indicating significant dilution by waters of Lake Erie.



PORT STANLEY

CHLOROPHYLL A COMPARISIONS OF 1978 & 1979

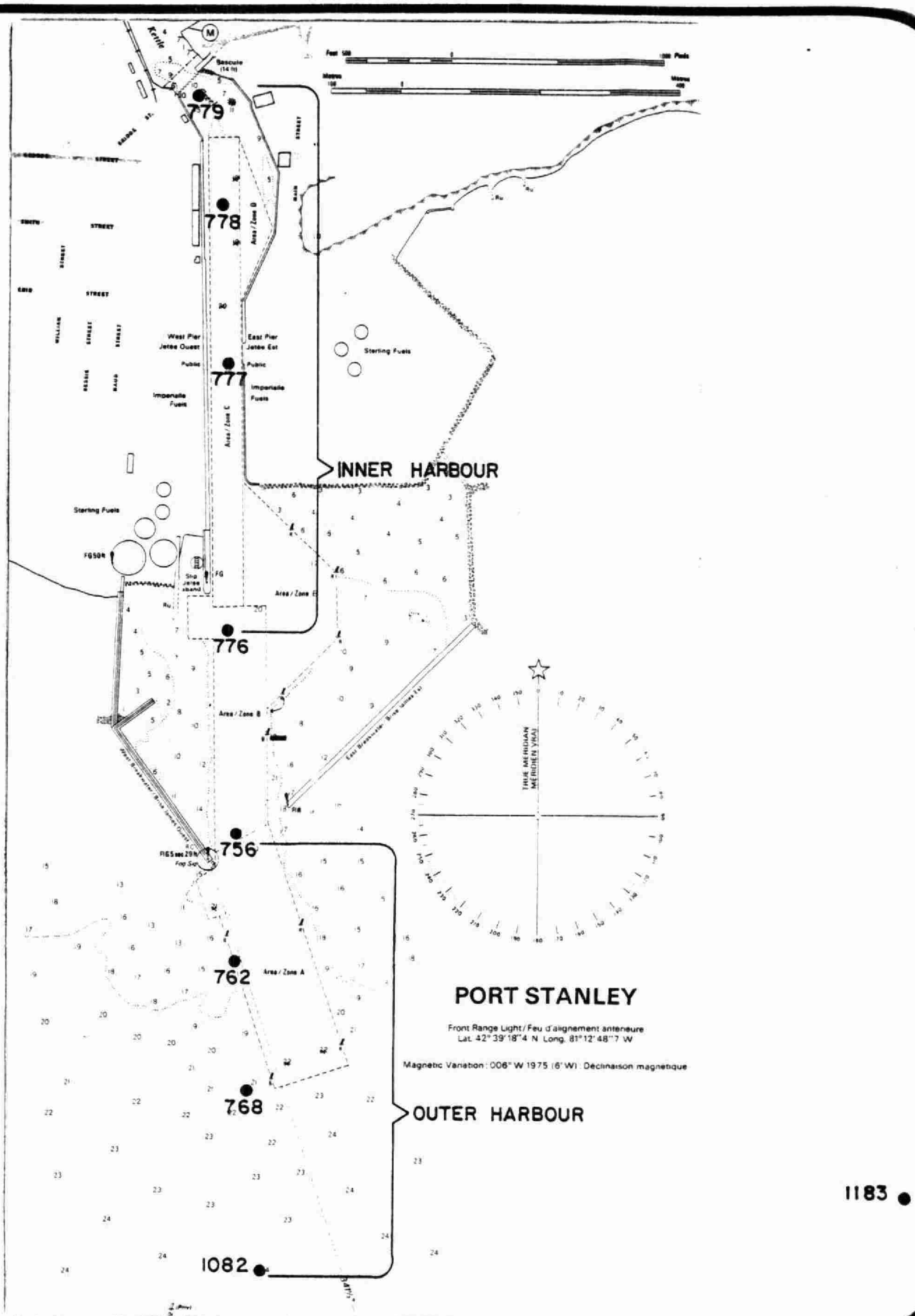
FIGURE 4



PORT STANLEY

FECAL COLIFORM COMPARISIONS OF 1975 & 1979

FIGURE 5

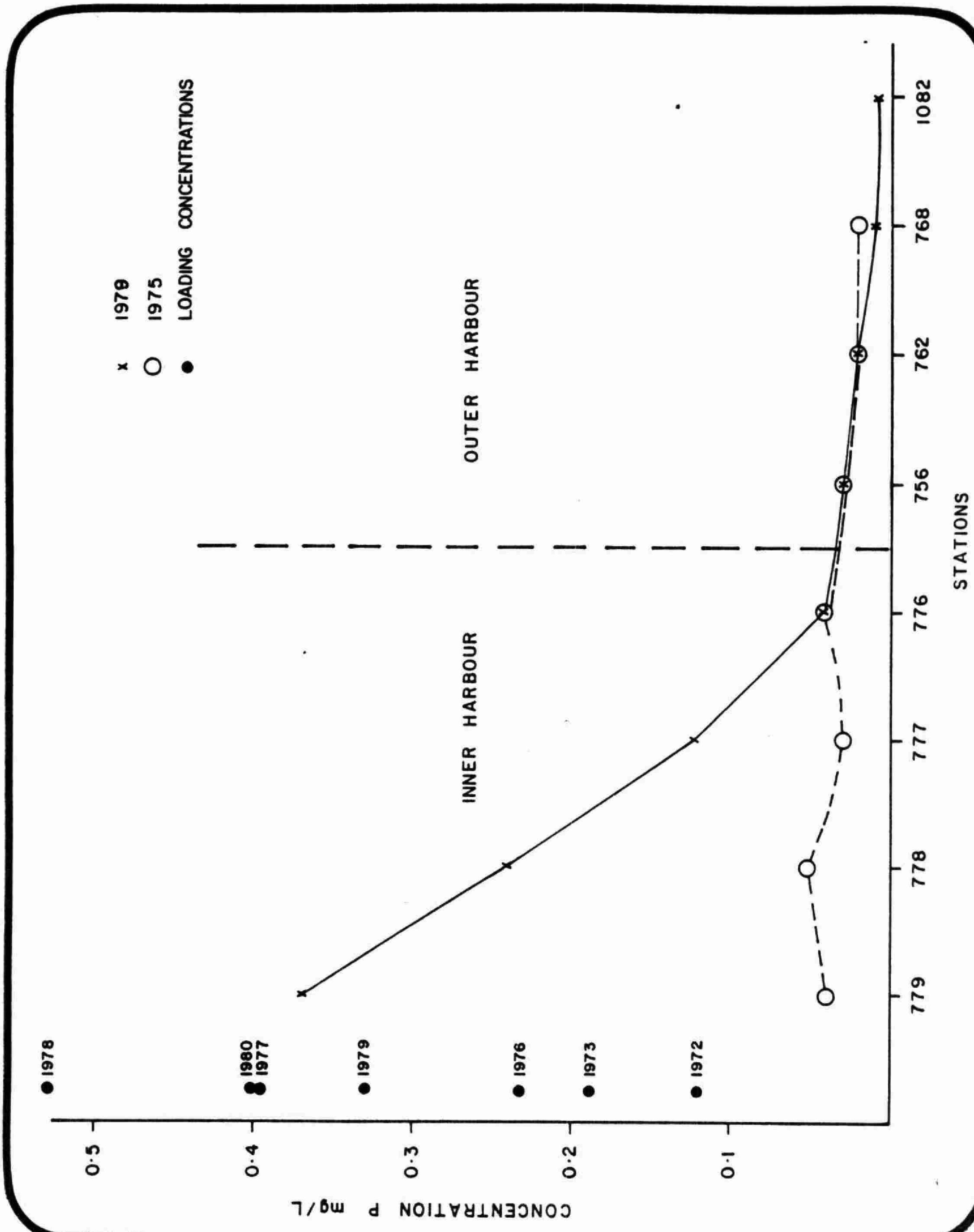


PORT STANLEY

WATER QUALITY STATIONS

SCALE: 1: 7,200

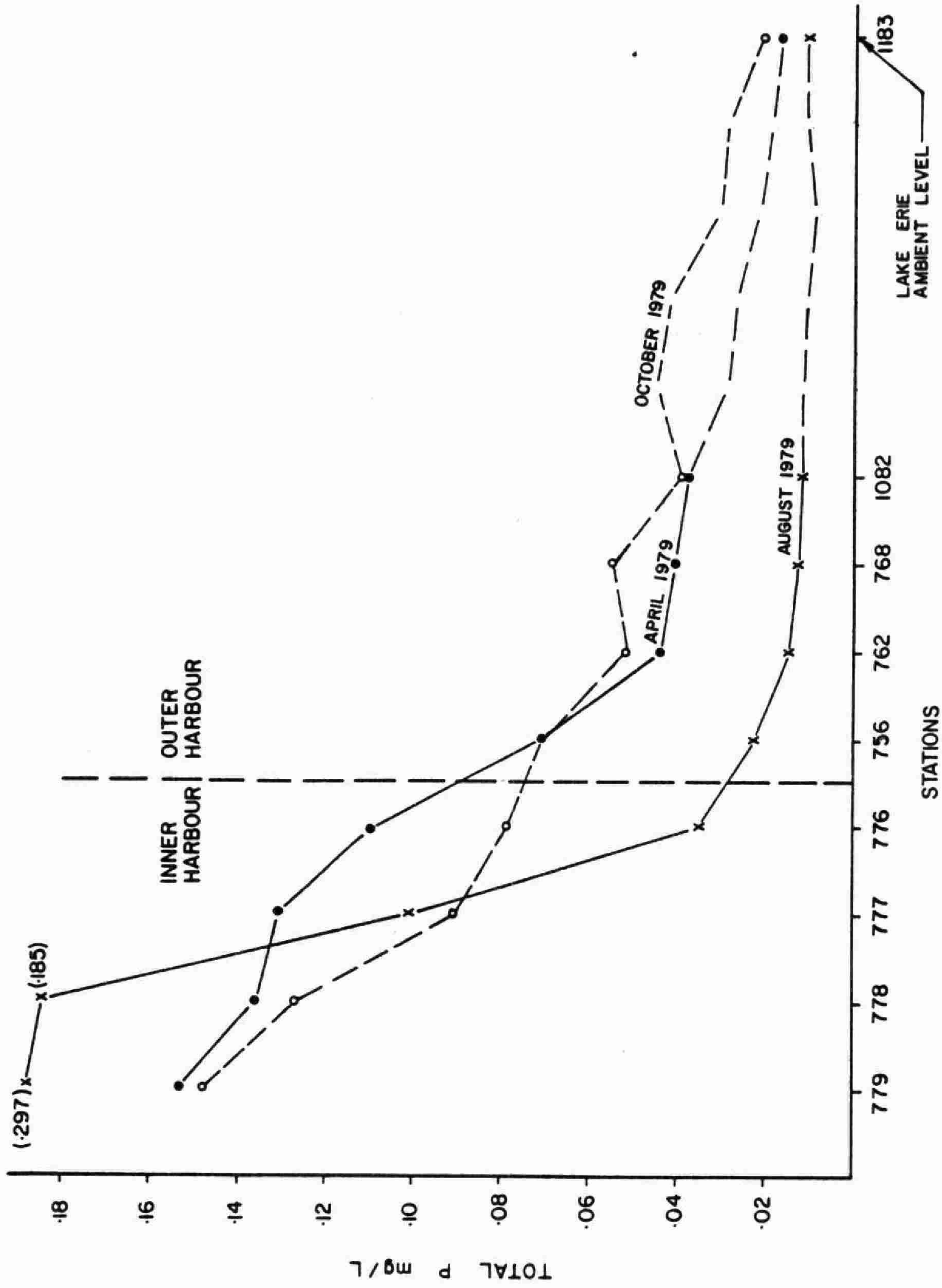
FIGURE 6



PORT STANLEY

TOTAL PHOSPHORUS CONCENTRATIONS

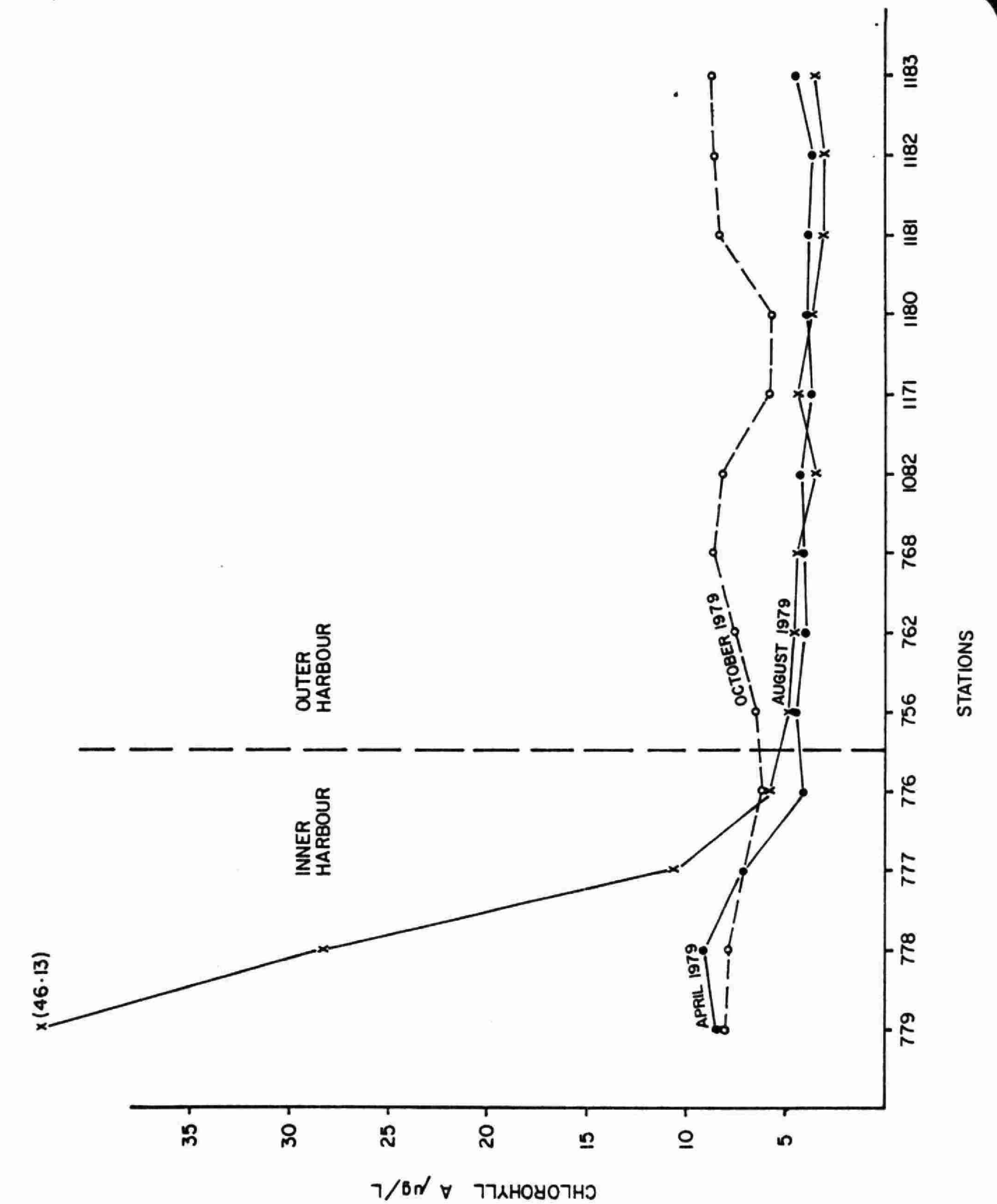
FIGURE 7



PORT STANLEY

1979 CRUISE DATA TOTAL P

FIGURE 8



PORT STANLEY

1979 CRUISE DATA CHLOROPHYLL A

FIGURE 9

5.0 PORT BURWELL

5.0 PORT BURWELL

5.1 Introduction

Port Burwell is not as active an industrial port as Port Stanley. It does, however, harbour a small commercial fishing operation and is used for water based recreation. This harbour is at the mouth of Otter Creek which drains a predominantly rural watershed. The town of Tillsonburg is the largest community within this watershed. This town has a conventional secondary treatment plant with phosphorus removal which discharges an average 1.8 MIGD to Big Otter Creek.

5.2 Historical Water Quality

No data were available for Port Burwell prior to 1978, consequently, MOE Water Quality Data for Ontario Lakes and Streams was obtained. Station 16-0109-005-02 data from Big Otter Creek at Highway 19 in Vienna are presented in Table 4.

Water quality of Big Otter Creek fluctuates widely from year to year. This table shows that in 1977 and 1980 water quality was particularly poor. Nutrients, conductivity, turbidity and bacteria levels were all high indicating poor water quality.

Data from a lake transect adjacent to Port Burwell taken in 1978 shows more eutrophic conditions at nearshore stations. Phosphorus, chlorophyll and nitrogen all decrease with increasing distance from shore. No influence of Big Otter Creek was noted in this transect water quality data.

5.3 Water Chemistry

Three water quality stations were sampled on 21 - 23 April, 22 - 23 August and October 30 to November 3, 1979. Locations of these stations are shown on Figure 10. The data are presented in Table 5.

TABLE 4

PORT BURWELL: BIG OTTER CREEK WATER QUALITY

	1976	1977	1978	1979	1980
Nutrients & Productivity					
Ammonia	0.028±.034 0.005-0.115	0.109±0.162 0.005-0.340	0.070 0.005-0.555		0.023±0.018 0.010-0.060
Total Kjeldahl Nitrogen	0.576±0.184 0.315-0.890	0.489±0.718 0.310-2.180	0.573±0.399 0.290-1.780	0.478±.094 0.320-0.620	1.018±0.556 0.380-2.300
Nitrate & Nitrite	2.137±1.476 0.433-5.624	2.56±1.83 0.879-7.273	1.781±0.804 1.157-4.04	2.927±1.433 1.101-5.126	3.812±1.756 1.758-8.918
Total Phosphorus	0.104±0.074 0.035-0.268	0.256±.246 0.039-0.765	0.130±.107 0.034-0.130	0.077±.028 0.042-0.129	0.263±0.486 0.034-1.080
Total Reactive Phosphorus	0.017±.017 0.003-0.061	0.039±.035 0.004-0.107	0.022±.029 0.003-0.105	0.019±0.14 0.002-0.049	0.050±0.068 0.008-0.765
Dissolved Constituents					
Conductivity µmhos	531±45.25 433-600	501±.88 315-600	526±60.66 349-582		564 472-610
Chloride	16.3±1.78 14.5-20.0	18.2±9.5 13.5-30.0	17.6±2.13 14.5-23.0		19.8±2.46 17.5-24.5
Oxygen (% saturation)	116.3 90.3-147.8	99.9 87.6-121.5	105.8 84.9-132.1	96.4 81.1-120	98.4 94.5-108.9
Transparency					
Turbidity FTU	25.51±16.61 4.60-61.00	98.57±109.4 9.30-330.00	31.97±37.81 5.10-140.00		43.26±24.83 8.30-75
Microbiology					
Total Coliform/100 ml	712 70-21000	2836 224-50000	944 170-17100	830 530-1306	4265 330-21000
Fecal Coliform/100 ml	77 4-700	142 20-770	88 10-1250	162 72-600	214 20-780
Pseudomonas/100 ml	4 0-24	8 4-760	4 4-8	4 4-4	8 4-88
Flows cms year $\bar{x}$	5.24	4.86	4.18	5.38	

Key: Mean ± Stop Dev.
Min-Max

TABLE 5

PORT BURWELL: 1979 WATER QUALITY DATA

STATION #	1239			1240			1241		
MONTH	APRIL	AUGUST	NOVEMBER	APRIL	AUGUST	NOVEMBER	APRIL	AUGUST	NOVEMBER
Nutrients & Productivity									
Ammonia	0.040±0.009 0.035-0.050	0.010±0.005 0.005-0.015	0.022±0.004 0.020-0.025	0.040±0.009 0.035-0.050	0.008±0.003 0.005-0.010	0.022±0.004 0.020-0.025	0.042±0.017 0.025-0.060	0.017±0.008 0.010-0.025	0.022±0.004 0.020-0.025
Total Kjeldahl Nitrogen	0.603±0.073 0.520-0.660	0.427±0.015 0.410-0.440	0.500±0.099 0.430-0.570	0.530±0.026 0.510-0.560	0.363±0.072 0.280-0.410	0.485±0.049 0.450-0.520	0.443±0.155 0.290-0.600	0.443±0.006 0.440-0.450	0.350±0.042 0.320-0.380
Nitrate & Nitrite	2.80±0.36 2.50-3.20	1.137±0.491 0.580-1.510	3.075±0.460 2.750-3.400	2.80±0.20 2.60-3.00	0.970±0.739 0.120-1.460	3.000±0.0 3.000-3.000	2.01±1.36 0.44-2.90	0.640±0.426 0.200-1.050	0.675±0.573 0.270-1.080
Total Phosphorus	0.095±0.013 0.082-0.109	0.069±0.007 0.063-0.076	0.080±0.018 0.067-0.093	0.086±0.003 0.084-0.090	0.043±0.022 0.018-0.058	0.080±0.004 0.077-0.083	0.065±0.032 0.028-0.085	0.131±0.072 0.064-0.208	0.096±0.037 0.070-0.122
Total Reactive	0.018±0.001 0.016-0.019	0.006±0.001 0.005-0.006	0.007±0.0 0.007-0.007	0.023±0.014 0.013-0.039	0.004±0.002 0.002-0.006	0.008±0.003 0.006-0.010	0.009±0.004 0.005-0.012	0.006±0.0 0.006-0.006	0.006±0.001 0.006-0.007
Silicate	2.89±0.060 2.82-2.94	2.35±0.89 1.32-2.90	3.70±0.0 3.70-3.70	2.90±0.080 2.82-2.96	2.91±0.08 2.84-3.00	3.87±0.24 3.70-4.04	2.88±0.040 2.84-2.92	1.87±1.17 0.60-2.90	0.68±0.0 0.68-0.68
Chlorophyll A	4.10±0.62 3.6-4.8	15.97±0.71 15.20-16.60	4.75±0.21 4.60-4.90	3.50±0.66 3.1-4.3	15.67±3.27 11.90-17.70	5.10±0.42 4.80-5.4	3.53±0.84 3.0-4.5	13.70±6.80 6.80-20.40	4.60±0.71 4.10-5.10
Corrected Chlorophyll A	2.60±1.39 1.1-3.8	12.20±0.62 11.70-12.90	3.60±0.28 3.40-3.80	1.70±0.70 0.9-2.2	11.17±1.93 9.00-12.70	1.30±1.56 0.20-2.40	1.93±1.62 1.0-3.8	7.77±2.58 4.80-9.50	2.60±1.41 1.60-3.60
Dissolved Constituents									
Conductivity μmhos	523±4 518-525	466±71 385-520	590±42 560-620	525±5 520-530	502±11 495-515	600±28 580-620	523±6 519-530	428±101 320-520	355±56 315-394
Chloride	16 16-16	20.17±0.29 20.00-20.50	22.00±0.0 22.00-22.00	16±0.6 16-17	20.33±0.29 20.00-20.50	20.50±3.54 18.00-23.00	16±0.6 16-17	20.17±0.29 20.00-20.50	19.00±0.0 19.00-19.00
Oxygen (% saturation)	85 86-89	79.7 71-87	91 91-91	89.3 86-91	90 80-99	90 90-90	89.3 86-94	80.7 72-91	91 91-91
Transparency									
Turbidity FTU	36±6 30-41	33.00±1.00 32.00-34.00	27.00±8.49 21.00-33.00	33±8 27-42	38.00±13.00 30.00-53.00	33.50±0.71 33.00-34.00	29±6 24-36	64.00±42.23 27.00-110.00	82.50±13.44 73.00-92.00
Secchi Disc meters	0.20 0.20-0.20			0.20 0.20-0.20			0.27±0.06 0.20-0.30		
Metals									
Iron		1.55±0.13 1.40-1.65	1.73±0.66 1.26-2.20		2.43±1.17 1.40-3.70	2.47±0.18 2.34-2.60		3.37±1.96 1.30-5.20	3.78±2.15 2.26-5.30
Microbiology									
Heterotrophic bacteria		41,885 34500-60000	75,000 75000-75000		52,452 31000-95000	75,000 75000-75000		54,974 35500-90000	42,450 34000-53000
Total Coliform/100 ml		1,249 1000-1500	3,857 1600-9300		1,936 1000-3300	2,929 1100-7800		1,227 400-2200	980 800-1200
Fecal Coliform/100 ml	37 28-48	65 40-116	363 220-600	86 72-104	152 84-328	259 112-600	30 20-44	96 40-244	120 120-120
Fecal Streptoccoi/100 ml	14 12-16	40 12-272	224 84-600	14 8-24	44 12-348	235 92-600	7 4-12	52 32-84	89 36-220
Pseudomonas/100 ml		8 4-8	9 4-20		11 4-88	4 4-4		14 4-4	4 4-4

Key: Mean±SD
Min-Max

5.3.1 Nutrients and Productivity

Ammonia levels at all stations was found to be quite low with a maximum recorded concentration of 0.06. This information indicates that any discharge sources must be some distance away.

Total Kjeldahl Nitrogen values are generally slightly higher than normally found in unpolluted waters. The maximum concentration found was 0.66 mg/l indicating only slightly impaired conditions.

Nitrate and Nitrite levels were also found to be quite low at all stations and well within Provincial objectives.

Total Phosphorus was elevated in almost all samples taken and sufficient to encourage the growth of algae. Figure 11 shows very high Total P values, far in excess of MOE objectives for aesthetic deterioration of 10 ug/l, even ambient levels at Station 1187 are above objective values. Figure 12 shows Big Otter Creek exceeds MOE objectives for Total P values in rivers and streams of 30 ug/l. All stations exceed Provincial Total P objectives.

Total Reactive Phosphorus was, however, quite low indicating that most of the phosphorus was not available for plant growth.

Silicate values remained relatively constant throughout the study period except at Station 1241 near the mouth of the harbour. The variability at this station may reflect dilution with waters of Lake Erie.

Chlorophyll A values reach a peak at all stations in August indicating a large algal biomass at that time. Corrected chlorophyll a data indicate that in the spring and fall these waters are oligotrophic and that they turn eutrophic in the summer (Figure 12). Figure 12 shows chlorophyll A values following the same trend as Total P values.

5.3.2 Dissolved Material

Conductivity values ranged from 315 to 620 umhos during the study period. Thus the Agreement Objective of 300 umhos was always exceeded. These levels indicate that conditions for aquatic life are only fair.

Chloride levels fluctuated close to 20 mg/l indicating the rural nature of the watershed.

5.3.3 Oxygen Saturation

Oxygen saturation fluctuated more than at previous stations but always within Provincial and Agreement Objectives levels (Figure 12).

5.3.4 Transparency

Turbidity was high at all stations during the period sampled. These data indicate eutrophic conditions. Station 1241, closest to the open lake, showed the highest levels of turbidity which indicates that river loadings are not the cause of this condition.

5.3.5 Metals

Iron concentrations near Port Burwell were exceedingly high. All values reported were well above objectives. Some concentrations were higher than maximum levels reported from Hamilton Harbour. Reasons for these high values cannot be explained with existing information. Station 1239 in Big Otter Creek had the lowest iron levels while Station 1241 in Lake Erie had the highest. This suggests Big Otter Creek is not a major source of iron to Lake Erie (Figure 13).

5.4 Microbiology

Total heterotrophic bacteria levels were high, reaching an average of 75,000 in August. This indicates eutrophic conditions. Heterotrophic bacteria were more numerous inside the harbour at Stations 1239 and 1240

than at Lake Erie Station 1241. Thus it appears Big Otter Creek is the source of these bacteria.

Total coliform numbers were also elevated, and exceeded Provncial and Agreement Objectives most of the year. Lowest values were obtained in April and highest values in November for all three stations. Station 1241, at the harbour mouth, had the lowest number of coliforms indicating a watershed source for this contamination.

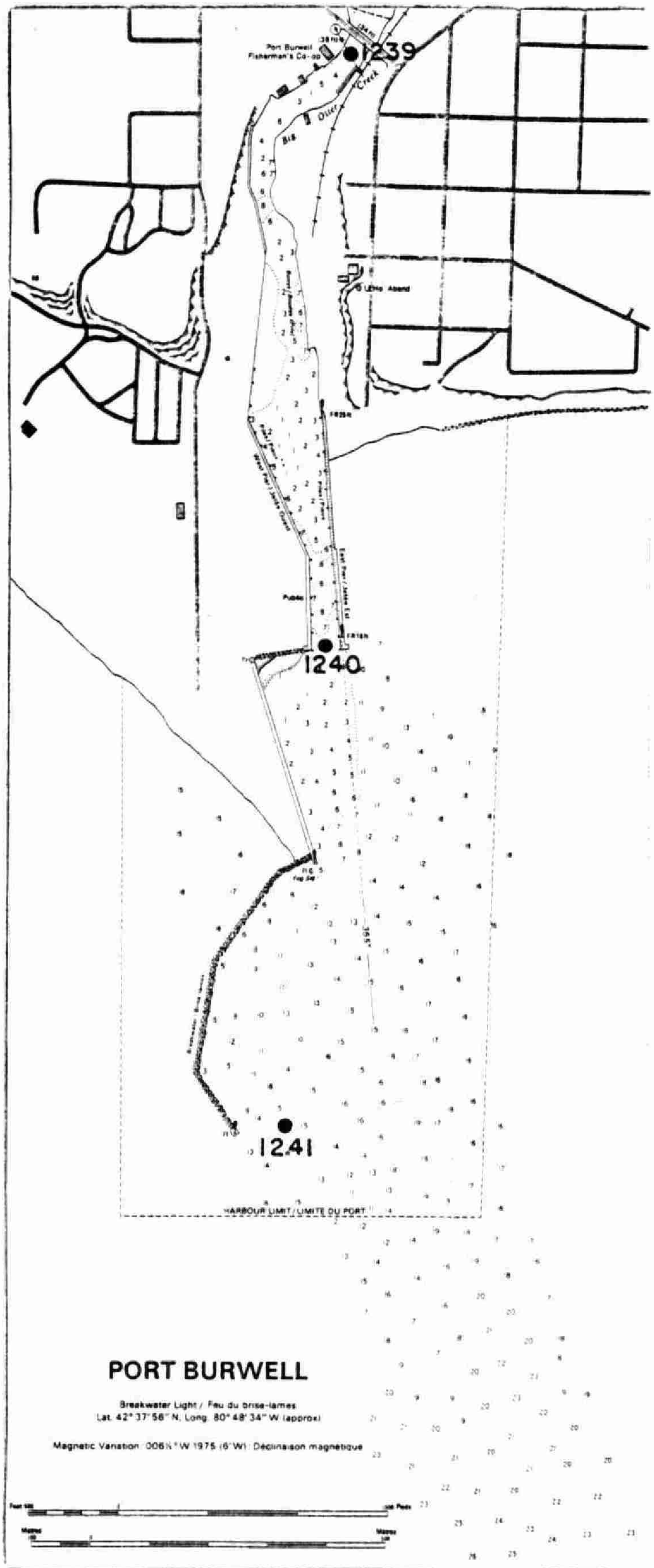
Fecal coliform numbers were also in excess of established objectives. The fecal coliform/fecal streptococci ratio however, was less than 4 and greater than 0.7. This indicates either a mixture of sources or that inputs of bacteria are well upstream of the study area. The largest number of coliform bacteria were also found in November at all three stations (Figure 14).

Pseudomonas values were consistently high suggesting the harbour is unsuitable for water contact recreation.

5.5 Summary

Water quality parameters examined within Port Burwell indicate that this body of water is moderately eutrophic. Secchi depth and bacterial levels indicate that swimming and other water contact recreation may pose a health risk.

Sources of material causing poor water quality in this harbour were thought to be associated with watershed rather than port activities.

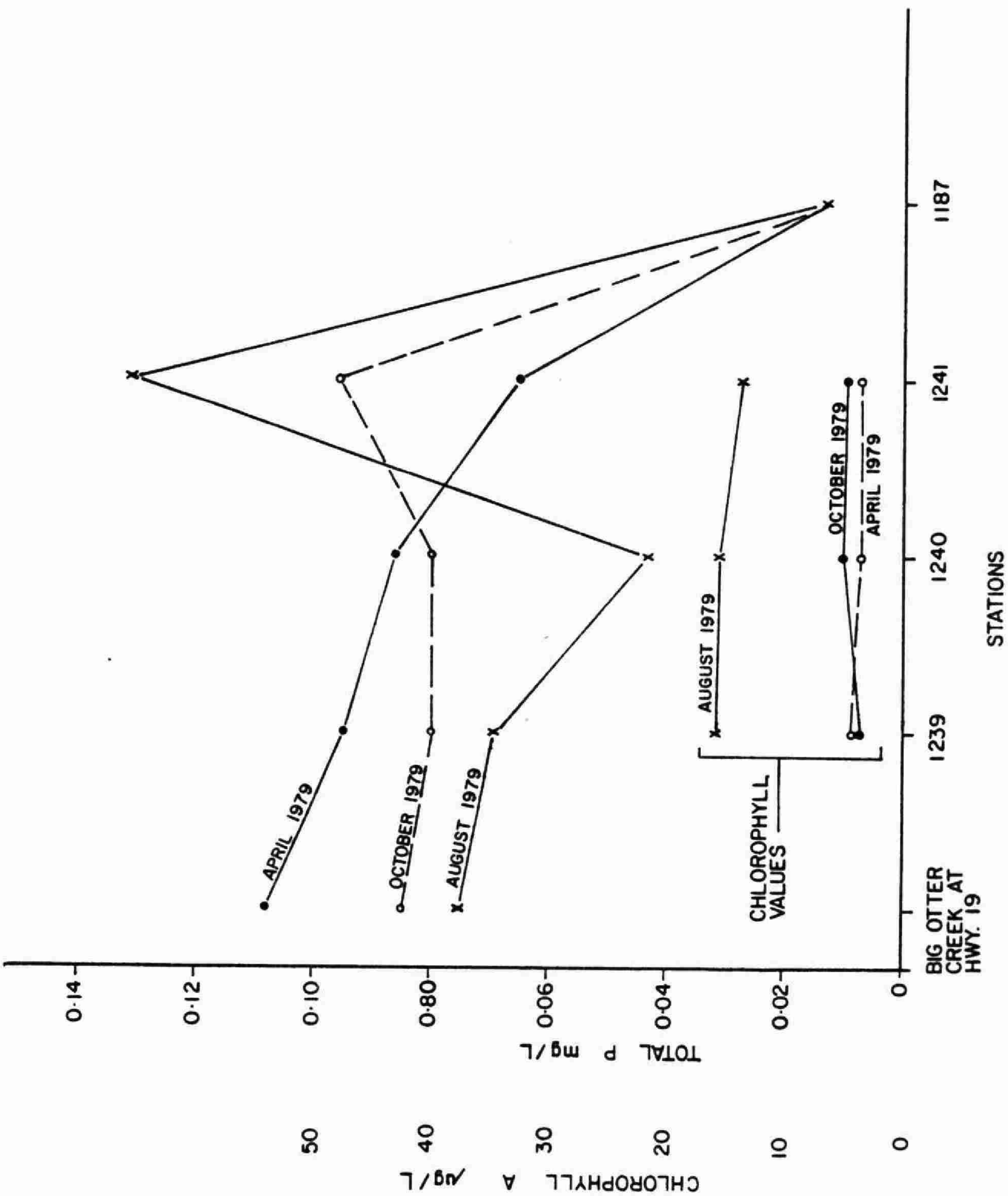


PORT BURWELL

WATER QUALITY STATIONS

SCALE 1:10,800

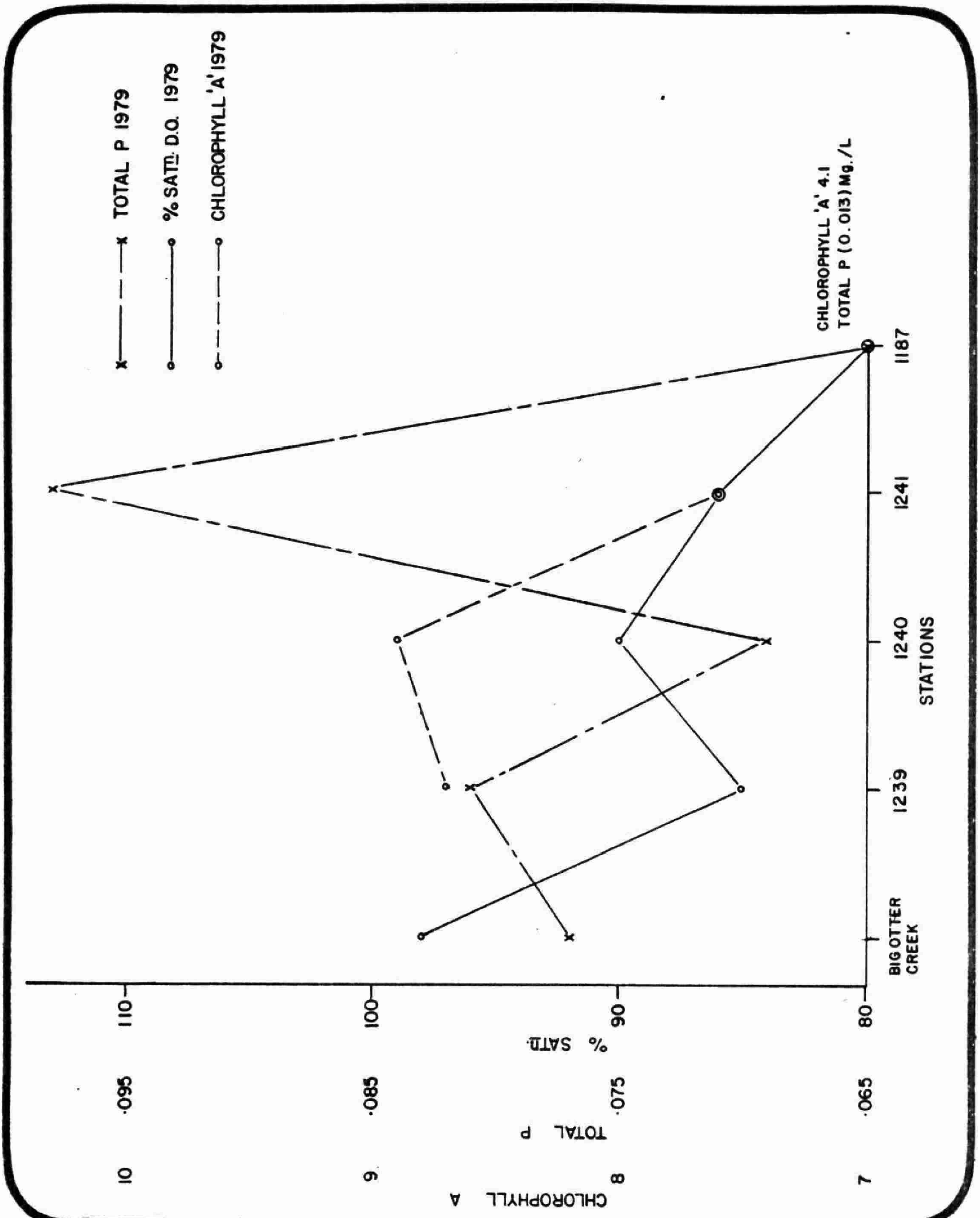
FIGURE 10



PORT BURWELL

1979 CRUISE DATA CHLOROPHYLL A & TOTAL P

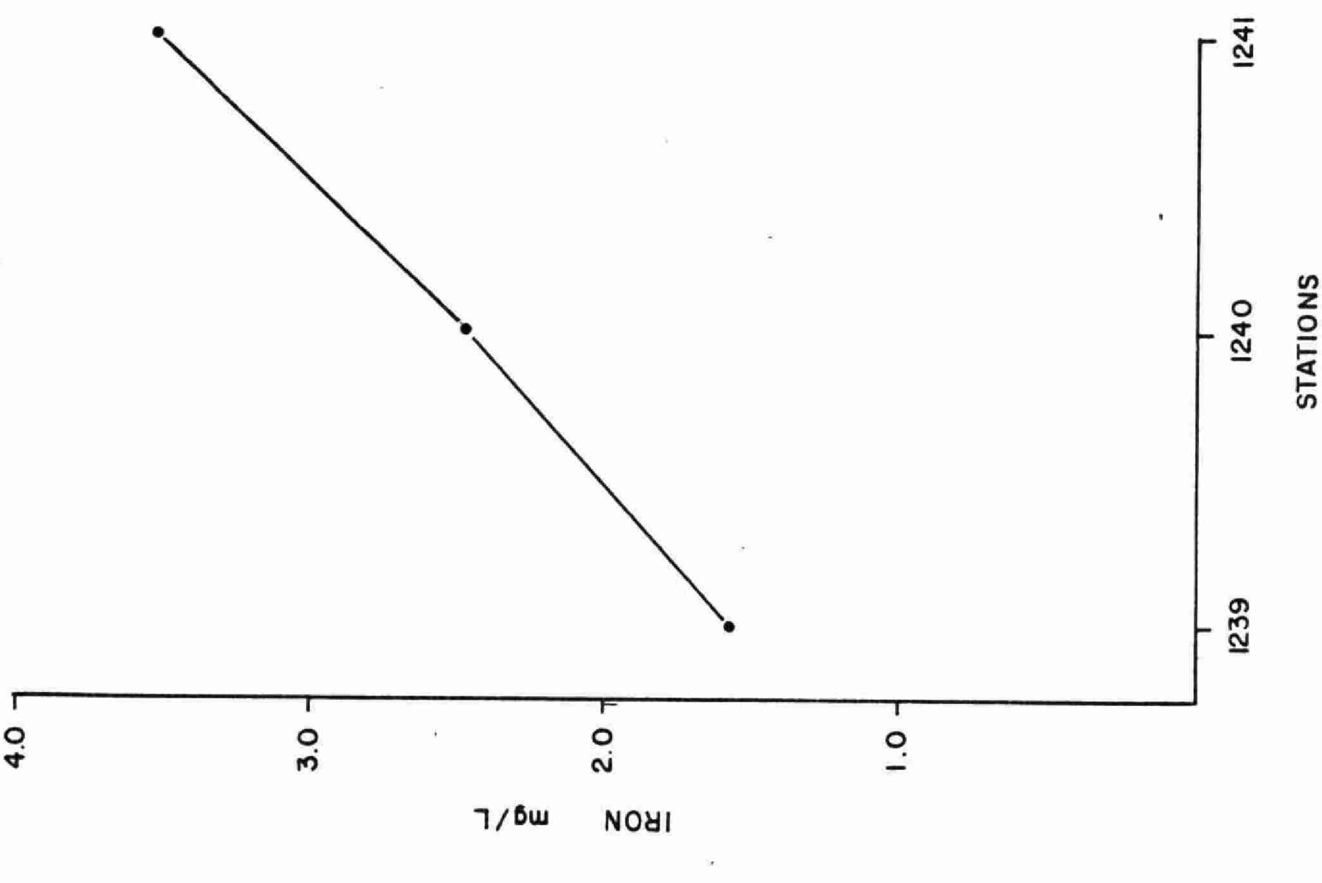
FIGURE 11



PORT BURWELL

MEAN 1979 VALUES TOTAL P % SATn. D.O. & CHLOROPHYLL A

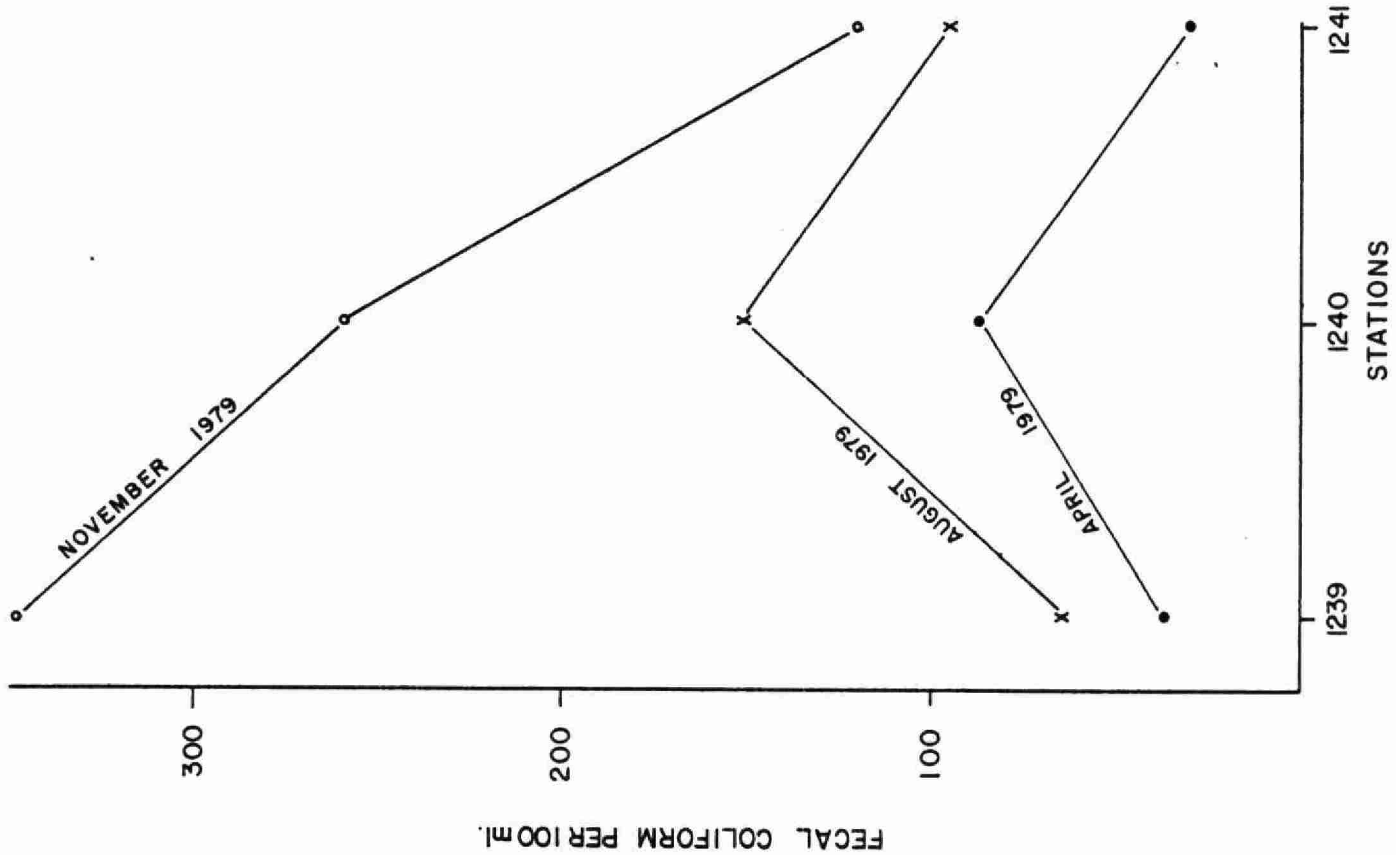
FIGURE 12



PORT BURWELL

MEAN 1979 VALUES IRON

FIGURE 13



PORT BURWELL

1979 CRUISE DATA FECAL COLIFORMS

FIGURE 14

6.0 PORT DOVER

6.0 PORT DOVER

6.1 Introduction

Situated on the Lynn River, Port Dover harbours a commercial fishing operation and a yacht club. Most of this watershed is intensively farmed. The Town of Simcoe is the major community in this watershed and is situated 8 to 9 kilometres upstream of the harbour. Simcoe has two activated sludge sewage treatment plants discharging 3.23 MIGD to the Lynn River. The effluent is polished in an automatic backwash rapid sand filter prior to discharge, but phosphorus removal is not practiced. The effluent contains an average 1.3 mg/l phosphorus when discharged.

Port Dover has a primary sewage treatment plant with a rated capacity of 0.9 MIGD and flows of 1.005 MIGD. The waste is chlorinated before discharge but no phosphorus removal is undertaken. The effluent from the plant contains an average 0.9 mg/l phosphorus when discharged.

6.2 Historical Water Chemistry

Ministry of the Environment historical water quality data upstream of Port Dover, and 1975 data from Stations 1 and 132 were reviewed. Both 1975 and 1979 harbour station data are presented on Tables 6 and 7. Comparisons of this data have revealed no differences in harbour station water quality between 1975 and 1979 (Figure 15). Dissolved oxygen levels at Station 1 have improved significantly since 1975. However, both 1975 and 1979 values complied with the MOE objectives. In 1975 water quality inside Port Dover harbour was degraded and it remains so in 1979. Although 1975 data are few it does appear that heterotrophic bacteria have increased during this time period.

6.3 Water Chemistry

In 1979 two water quality stations near Port Dover were sampled on April 29 to May 3, 25 - 27 June, 23 - 27 July, 8 - 12 September, 15 - 17 October, and 14 - 19 November. Station locations are shown on Figure 16, and the data presented in Tables 6 and 7.

TABLE 6

PORT DOVER: STATION 1, 1979 AND 1975 WATER QUALITY DATA

	1979						
MONTH	MAY	JUNE	JULY	SEPTEMBER	OCTOBER	NOVEMBER	1975 YEARLY AVG
Nutrients & Productivity							
Ammonia	0.106±0.027 0.078-0.132	0.131±0.007 0.126-0.136	0.166±0.031 0.014-0.078	0.119±0.041 0.074-0.152	0.098±0.02 0.078-0.118	0.067±0.009 0.062-0.071	0.143±0.026 0.04-0.23
Total Kjeldahl Nitrogen	0.82±0.08 0.75-0.91	0.74±0.042 0.71-0.77	0.66±0.07 0.51-0.67	0.72±0.08 0.64-0.73	0.607±0.08 0.52-0.68	0.573±0.079 0.56-0.58	0.602±0.109 0.450-0.78
Nitrate & Nitrite	1.27±.126 1.15-1.40	0.9±0.141 0.8-1.00	0.618±0.155 0.400-0.765	1.052±0.135 0.895-1.15	1.8±0.43 1.4-2.25	2.483±0.23 2.40-2.60	2.307 ±0.106 0.096-10.569
Total Phosphorus	0.103±0.023 0.078-0.123	0.125±0.012 0.116-0.134	0.070±0.009 0.060-0.082	0.067±0.007 0.059-0.073	0.066±0.023 0.046-0.091	0.062±0.084 0.051-0.067	0.077 ±0.028 0.042-0.130
Total Reactive Phosphorus	0.0183±0.005 0.014-0.024	0.033±0.013 0.024-0.042	0.0148±0.003 0.012-0.019	0.0117±0.002 0.010-0.013	0.023±0.005 0.018-0.028	0.016±0.04 0.012-0.020	0.026 ±0.007 0.012-0.049
Silicate	2.47±0.029 2.45-2.5	2.25±0.707 1.75-2.75	0.253±0.14 0.45-0.15	3.317±0.66 2.55-3.70	3.23±0.91 2.40-4.20	3.783±1.52 3.60-3.90	2.96 ±0.34 1.9-3.9
Chlorophyll A	6.2±1.97 4.0-7.8	9±8.1 3.3-14.7	38.95±22.0 21.2-68.5	12.5±4.3 7.7-16.0	3.37±0.12 3.3-3.5	2.975±1.27 1.9-4.8	9.7 2.2-24
Corrected Chlorophyll A	3.73±1.29 2.3-4.8	4.3±5.4 3.0-5.6	34.1±20.3 17.7-61.5	9.9±3.7 5.8-13.0	1.63±0.71 1.0-2.4	1.4±1.45 0.1-3.4	
Dissolved Constituents							
Conductivity	590±51.9 560-650	440±31.11 418-462	408.3±50.58 350-440	543.3±46.2 490-570	525±62.65 465-590	627.5±80.6 560-740	509±63.8 390-583
Chloride	23.3±1.04 22.5-24.5	26±1.06 25-27	31±4.5 31-31.5	36.17±2.75 33.0-37.5	28.5±2.78 25.5-31.0	36.125±9.63 28.5-50.0	26.1±1.48 23-30
Oxygen (% saturation)	87 85-88	98 84-112	93.5 51-115	77.3 73-84	86.7 82-95	92.2 87-97.6	81 51-97
Transparency							
Turbidity FTU	21±3.0 18-24	16±2.83 14-18	4.6±2.29 3.0-7.2	13±1.0 12-14	14.9±6.1 8.8-21	10.1±4.2 5.8-15	8.6±4.3 2.2-16
Secchi Disc meters	0.18± 0.10-0.20	0.25± 0.20-0.30	0.4± 0.30-0.60	0.5± 0.40-0.60	0.40± 0.20-0.60	0.325± 0.2-0.5	0.5 0.2-1.0
Metals							
Iron							
Microbiology							
Heterotrophic Bacteria	710000-750000	19500-30000	8000-23000	75000-170000	75000-TNTC	CNTLOW-75000	1250

Key: Mean
Min-Max

TABLE 7

PORT DOVER: STATION 132, 1979 AND 1975 WATER QUALITY DATA

	1979						
MONTH	MAY	JUNE	JULY	SEPTEMBER	OCTOBER	NOVEMBER	1975 YEARLY AVG
<u>Nutrients & Productivity</u>							
Ammonia	.0140±0.010 0.008-0.025	0.028±0.028 0.010-0.061	0.037±0.020 0.013-0.056	0.021±0.008 0.012-0.026	0.037±0.02 0.013-0.056	0.008±0.004 0.005-0.014	0.014±0.011 0.005-0.050
Total Kjeldahl Nitrogen	0.290±0.087 0.230-0.390	0.483±0.361 0.260-0.900	0.290±0.035 0.240-0.320	0.320±0.101 0.210-0.410	0.290±0.035 0.240-0.320	0.250±0.029 0.220-0.280	0.274±0.036 0.210-0.340
Nitrate & Nitrite	0.175±0.022 0.160-0.200	0.128±0.003 0.125-0.130	0.194±0.064 0.120-0.275	0.125±0.009 0.115-0.130	0.194±0.064 0.120-0.275	0.184±0.023 0.160-0.215	0.207±0.183 0.072-0.615
Total Phosphorus	0.014±0.004 0.010-0.017	0.016±0.006 0.010-0.021	0.015±0.005 0.011-0.022	0.014±0.006 0.009-0.020	0.015±0.005 0.011-0.022	0.016±0.006 0.010-0.024	0.010±0.001 0.080-0.013
Total Reactive	0.001±0.001 0.001-0.002	0.004±0.002 0.002-0.006	0.003±0.002 0.002-0.005	0.003±0.002 0.002-0.005	0.03±0.002 0.002-0.005	0.002±0.001 0.002-0.003	0.002±0.001 0.001-0.005
Silicate							0.15 0.1-0.25
Chlorophyll A	3.9±0.90 3.0-4.8	1.6±0.50 1.3-2.2	1.3±0.1 1.20-1.40	2.10±0.2 2.00-2.40	1.3±0.10 1.20-1.40	3.6±0.6 3.0-4.4	2.1 0.1-3.4
Corrected Chlorophyll A	1.87±0.31 1.60-2.20	0.40±0.10 0.30-0.50	1.23±0.12 1.10-1.30	1.43±0.32 1.20-1.80	1.2±0.12 1.10-1.30	2.80±0.65 2.00-3.50	
<u>Dissolved Constituents</u>							
Conductivity µmhos	327±33 308-365	305±0 305-305	304±2 302-306	306±1 305-307	304±2.00 302-306	304±5.0 300-310	299±6.428 285-310
Chloride	19.70±0.30 19.5-20.0	10.3±0.62 9.60-10.8	20.3±0.3 20.00-20.50	20.0±0.0 20.00-20.00	20.3±0.30 20.00-20.5	19.70±0.8 19.0-20.5	21.9±0.62 21-23
Oxygen (% saturation)	100.7 97-105	101 93-107	90.8 80-104	91.3 90-93	86.7 82-94	92 91-93	101 91-111
<u>Transparency</u>							
Turbidity FTU	1.73±0.42 1.40-2.20	1.6±0.35 1.20-1.80	1.97±0.45 1.50-2.40	2.63±0.51 2.20-3.20	1.97±0.45 1.50-2.40	2.27±0.21 2.20-2.60	1.33±0.32 0.80-1.8
Secchi Disc meters	2.2±0.3 2.20-2.50	3.3±0.50 3.0-4.0	2.8±0.5 2.2-3.5	2.40±0.50 2.00-3.00	2.80±0.50 2.20-3.50	1.80±0.20 1.50-2.00	2.3 1.0-3.5
<u>Metals</u>							
Iron	0.090±0.03 0.07-0.12	0.03±0.01 0.03-0.04	0.06±0.03 0.04-0.08	0.09±0.02 0.07-0.10	0.06±0.3 0.04-0.08	0.12±0.010 0.11-0.13	
<u>Microbiology</u>							
Heterotrophic Bacteria	71902 2350-22000	43337 3050-5350	1490 330-4400	2869 1650-5300	1490 330-4400	2190 650-29500	702 410-1400

Key: Mean±SD
Min-Max

6.3.1 Nutrients and Productivity

Ammonia levels are almost one order of magnitude higher at Station 1 than outside the harbour at Station 132. Provincial and Agreement Objectives were not exceeded at either station although concentrations approached 0.02 mg/l un-ionized ammonia inside the harbour.

Total Kjeldahl Nitrogen was twice as concentrated inside the harbour than in Lake Erie. Station 1 values ranged from 0.51 to 0.91 mg/l and were highest in May. These levels are higher than normally found in clean water. Station 132 values never exceeded 0.061 mg/l indicating clean water conditions.

Nitrate and Nitrite values were also considerably higher at Station 1. While these values were considerably higher than background, the Provincial public water supply objective of 10 mg/l was not exceeded. Concentrations of nitrate and nitrite showed seasonal peaks during May and November at Station 1, but were relatively constant at Station 132. Reasons for these peaks in the harbour may be related to peak runoff periods and agricultural practices in the watershed. The lack of fluctuating levels at Station 132 may reflect the capacity of Lake Erie to dilute these impaired harbour waters.

Total Phosphorus concentrations were also considerably higher within Port Dover harbour. While phosphorus levels in Lake Erie seldom exceeded the 0.02 mg/l criterion for algal growth, levels within the harbour were seldom less.

A great deal of Reactive Phosphorus was found at Station 1. Levels ranged from 0.010 to 0.042 mg/l inside this harbour. Reactive phosphorus is available for plant growth. Consequently, algae blooms may be a problem in this harbour.

Silicate values decreased significantly in July at about the same time chlorophyll A values peaked. This data indicates a large growth in the diatom community during this month.

Chlorophyll A values showed a spring and fall peak at Station 132 in the open lake. This growth pattern is typical of oligotrophic and mesotrophic lake systems. The single peak of chlorophyll at Station 1 was considerably larger, occurred in July, and indicates eutrophic conditions (Figure 17). Little phaeophytin was present during this bloom indicating a very healthy and growing plant community.

6.3.2 Dissolved Material

Conductivity in Lake Erie (Station 132) fluctuates at about 300 to 310 umhos. This is approximately the Agreement Objective and provides good protection for aquatic life. Inside the harbour conductivity fluctuates more widely between 400 to 600 umhos. These values indicate degraded water quality and offer fair to poor protection for aquatic life.

Chloride levels at Station 132 were reasonably consistent at about 20 mg/l which reflects lake wide values. The June value of approximately half this value is attributed to sampling error as no process is known which would decrease the level of chloride in a lake as large a Lake Erie during one month. Concentrations of chloride were somewhat higher inside the harbour ranging from 22.5 to 50 mg/l. Reasons for the higher chloride levels within the harbour may partially be attributed to chlorination of effluent at the two upstream sewage treatment plants. Increased levels of chloride do not however account for the increase in conductivity noted.

6.3.3 Oxygen Saturation

Concentration of dissolved oxygen in the surface waters of both Port Dover stations always remained well above the minimum saturation values recommended by MOE. Saturation decreased slightly in September and October at these stations but not enough to affect aquatic life.

6.3.4 Transparency

Turbidity within Port Dover harbour fluctuated between 13 and 21 FTU during the season and reached a low of 3 FTU in June. The Lake Erie station turbidity was considerably less ranging from 1.2 to 3.2 FTU. These Lake Erie values are considerably lower than all stations to the west but not as low as at Port Colborne to the east. From these data Lake Erie water, at this point, would be considered oligotrophic and harbour water mesotrophic.

Secchi disc depth data also shows the Lake Erie station (132) to have clearer water than any other lake station noted. Inside the harbour Secchi disc depth was only 0.2 to 0.4 metres while in the open lake it was visible up to 3.5 metres.

6.3.5 Metals

No data on iron was available inside the harbour, however, levels in the lake never exceeded Provincial or Agreement Objectives of 0.3 mg/l. This contrasts with waters off Rondeau Harbour, Port Stanley and Port Burwell where levels exceeded objectives frequently.

6.4 Microbiology

Heterotrophic bacteria numbers within Port Dover harbour were the highest of any station sampled. Values as high as 750,000 were recorded in May with a low of 8,000 in July. Number of bacteria in Lake Erie (Station 132) were also quite elevated, although substantially lower than within the harbour. Values ranged from 330 to 29,500 per 100 ml.

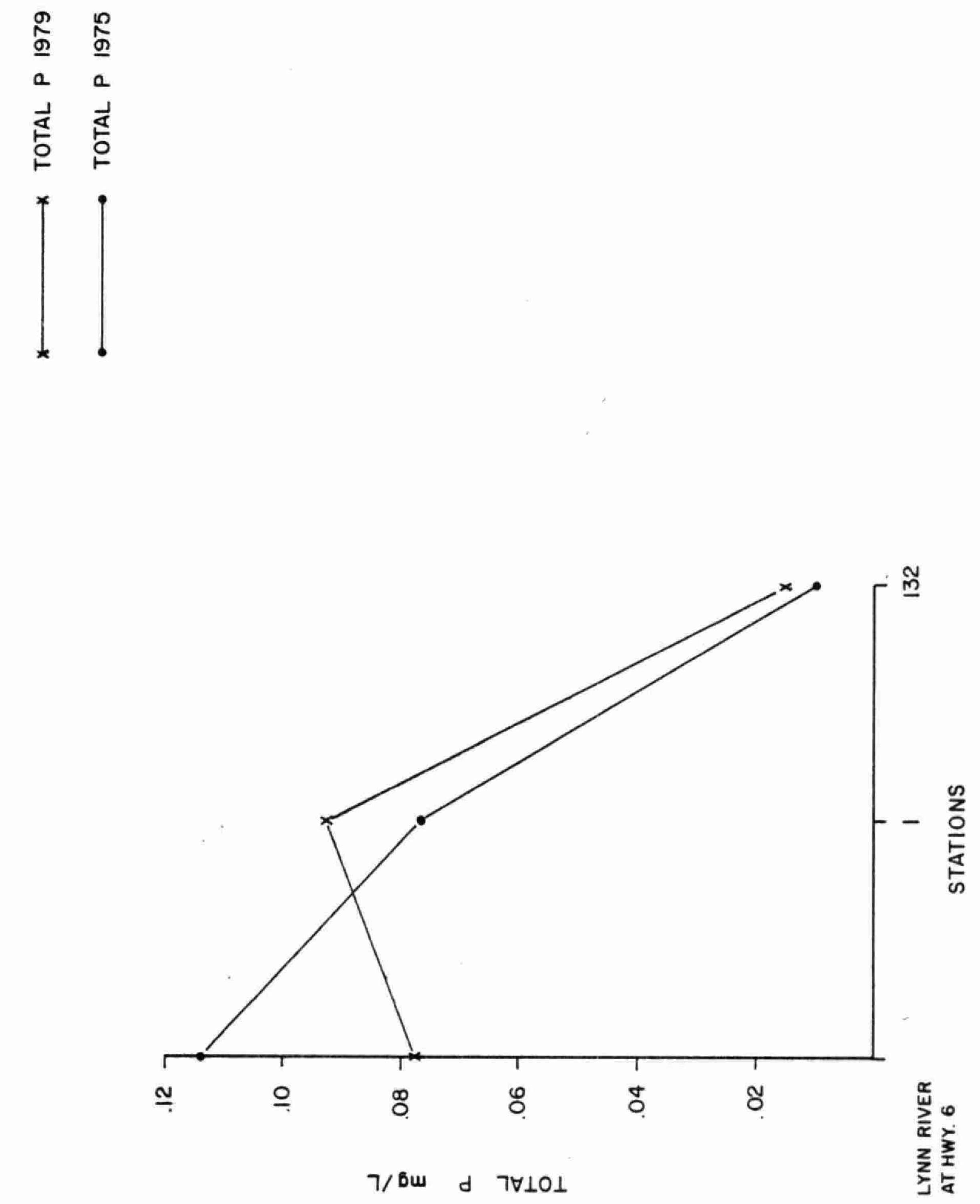
This data indicates degradation of water within the harbour resulting in eutrophic conditions most of the year. Data at Station 132 indicate Lake Erie to be mesotrophic with a tendancy to become eutrophic in the spring.

Unfortunately, other data on the microbial components of these waters were not collected.

6.5 Summary

In general, water quality within Port Dover harbour was impaired and subject to wider fluctuations than water in Lake Erie. Nitrogen, phosphorus, chlorophyll, conductivity, chloride, oxygen saturation, turbidity, Secchi depth and number of heterotrophic bacteria all indicated poorer water quality at Station 1 than Station 132.

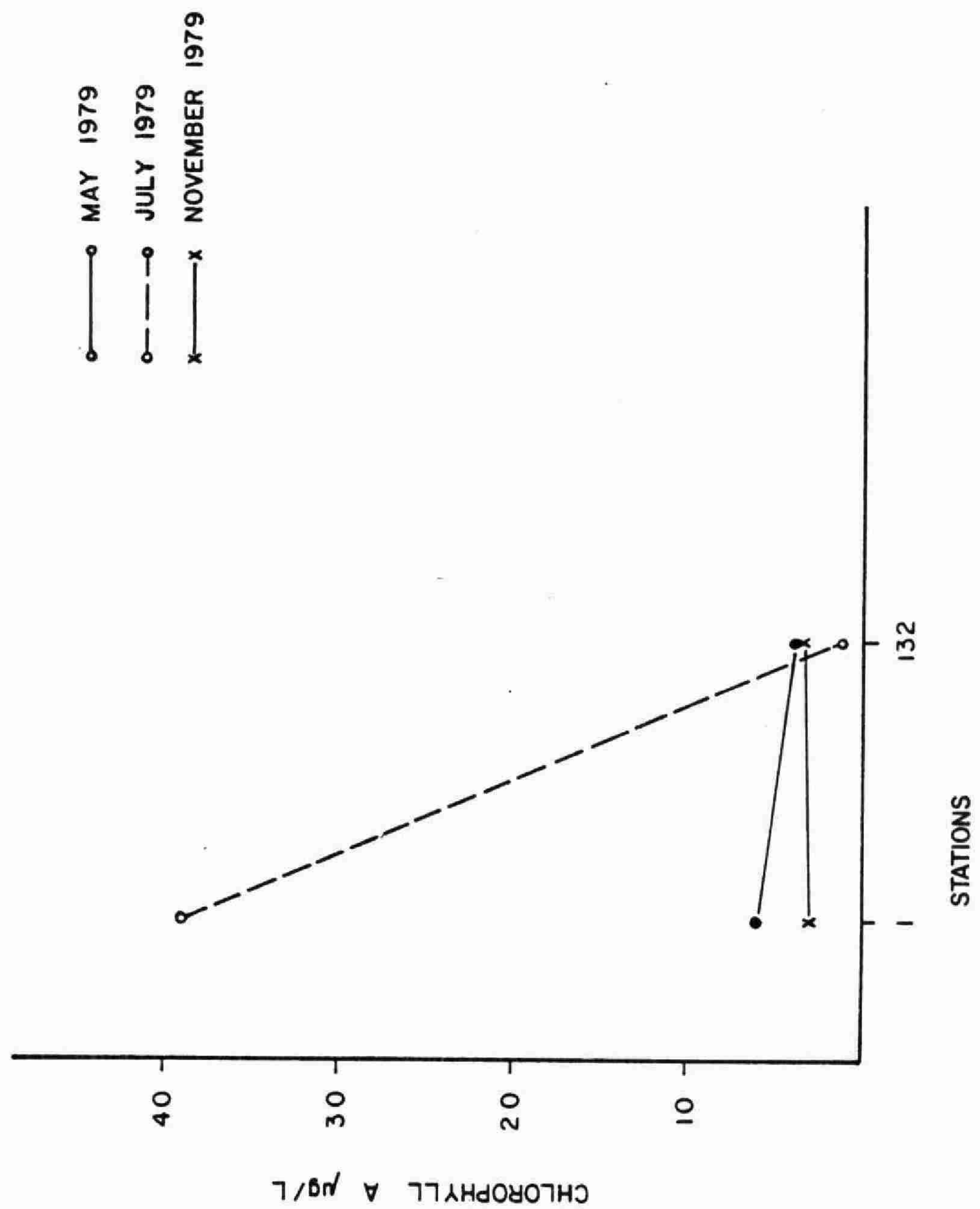
Historical data indicated that between 1975 and 1979, water quality has not changed appreciably at either of these stations. Water quality degradation was attributed to watershed activities, including farming, urbanization and sewage discharges.



PORT DOVER

TOTAL P COMPARISONS - 1975 & 1979

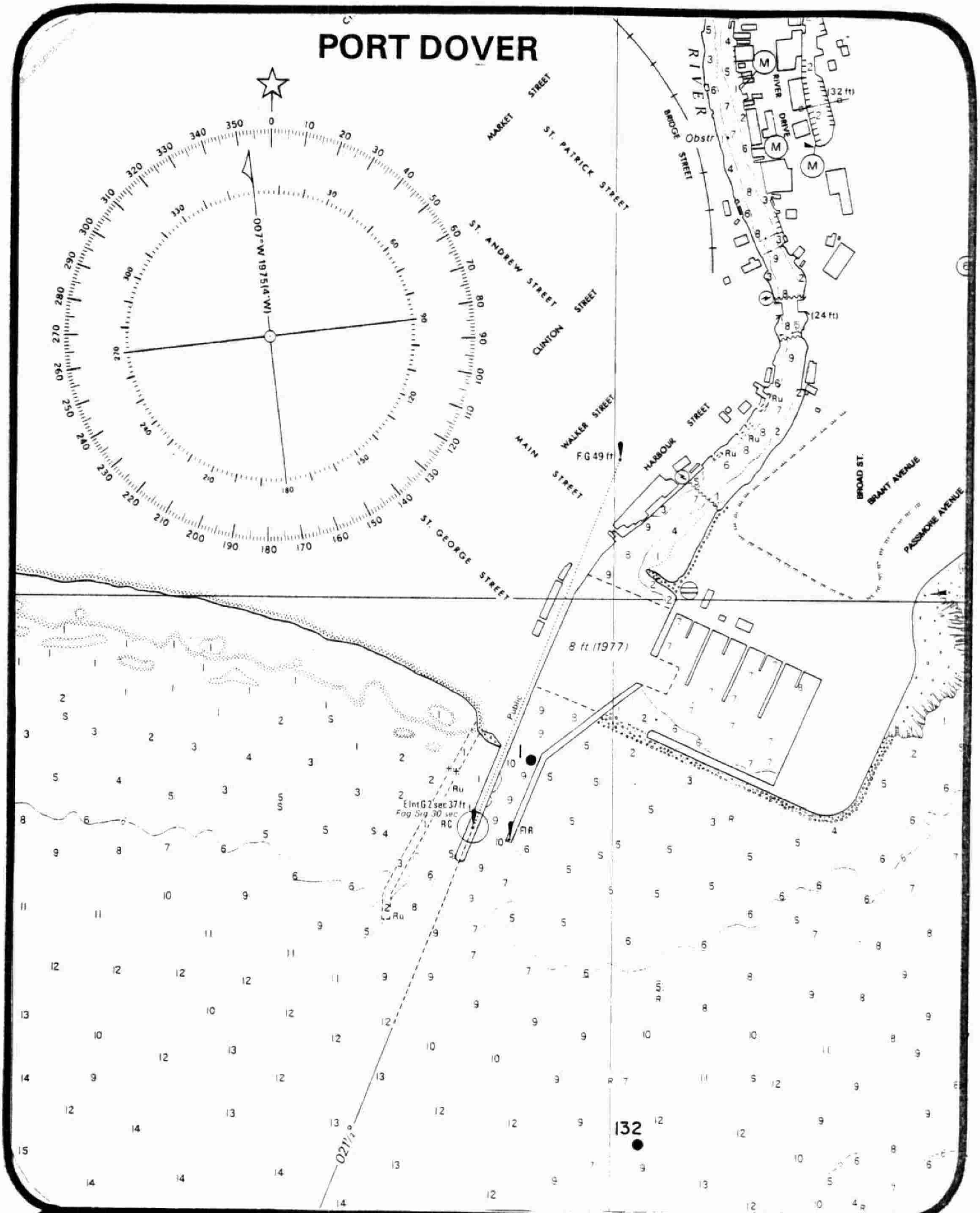
FIGURE 15



PORT DOVER

1979 VALUES CHLOROPHYLL A

FIGURE 16



PORT DOVER

WATER QUALITY STATIONS

SCALE 1: 4,800

FIGURE 17

7.0 PORT COLBORNE

7.0 PORT COLBORNE

7.1 Introduction

Transect water quality sampling stations were established in all harbours to determine conditions within these harbours and detect influences to Lake Erie itself. Port Colborne is unique among Lake Erie harbours however, in that waters from Lake Erie flow into this harbour. This situation exists because Port Colborne is the upstream end of the Welland Ship Canal which empties into Lake Ontario. Consequently, land based and port activities at Port Colborne do not influence Lake Erie water quality but impact instead on the Welland Canal waters.

In 1978 and 1979 two sewage treatment plants discharged approximately 2 MIGD to the Welland Ship Canal near the MOE monitoring station (Figure 17). Between 1978 and 1979 treatment was improved at the West Plant and now has a BOD of 10 mg/l, suspended solids of 20 mg/l and phosphorus concentration of approximately 1 mg/l.

7.2 Historical Water Chemistry

Other than the 1978 data discussed in the next section, no historical water quality data for Port Colborne were reviewed.

7.3 Water Chemistry

Three water quality stations were sampled in 1978 on May 28 - 30, August 18 - 21, and November 4 - 6. In 1979 samples were taken at these stations May 8 - 11, June 17 - 19, August 3 - 5, August 28 - September 3, September 29 - October 2 and November 6 - 9. In addition, Welland Ship Canal data for both years was obtained from MOE Water Quality Data reports. Station locations are shown on Figure 17, and the data presented on Table 8.

7.3.1 Nutrients and Productivity

Ammonia levels were constant at all stations and showed an increase from approximately 0.008 mg/l in Lake Erie to 0.02 mg/l within the

TABLE 8

PORT COLBORNE: 1978 AND 1979 WATER QUALITY DATA

	1978				1979			
	Welland Ship Canal	1130	1131	1132	Welland Ship Canal	1130	1131	1132
Nutrients & Productivity								
Ammonia	0.019±0.0115 0.008-0.040	0.013±0.00545 0.004-0.026	0.0117±0.00238 0.006-0.016	0.008±0.00082 0.006-0.014	0.027±.049 0.006-0.174	0.015±0.0042 0.005-0.024	0.016±0.0051 0.006-0.044	0.01±0.0082 0.004-0.061
Total Kjeldahl N	0.285±0.075 0.140-0.410	0.273±0.0531 0.150-0.350	0.302±0.055 0.250-0.470	0.295±0.0574 0.230-0.420	0.273±0.0393 0.230-0.340	0.269±0.030 0.220-0.360	0.267±0.024 0.210-0330	0.286±0.056 0.200-0.350
Nitrate & Nitrite	0.190±0.079 0.057-0.293	0.124±0.0216 0.030-0.165	0.135±0.0304 0.080-0.205	0.143±0.0057 0.080-0.195	0.028±0.0856 0.017-0.434	0.212±0.022 0.150-0.505	0.204±0.032 0.110-0.475	0.194±0559 0.100-0.475
Total Phosphorus	0.021±0.0132 0.012-0.060	0.010±0.0039 0.003-0.015	0.008±0.001 0.007-0.010	0.008±0.0014 0.005-0.010	0.017±0.0046 0.011-0.024	0.014±0.003 0.006-0.020	0.014±0.004 0.006-0.021	0.016±0.0045 0.005-0.025
Total Reactive P	0.005±0.0037 0.001-0.012	0.003±0.0021 0.001-0.008	0.003±0.0014 0.001-0.004	0.002±0.001 0.001-0.003	0.006±0.012 0.001-0.042	0.002±0.009 0.001-0.004	0.002±0.001 0.001-0.004	0.003±0.0015 0.001-0.004
Silicate		0.075±0.029 0.050-0.125	0.094 0.050-0.150	0.106 0.050-0.250		0.072±0.0118 0.050-0.150	0.083±0.036 0.050-0.250	0.165±.129 0.050-0.650
Chlorophyll A						3.0±0.961 1.0 - 6.2	3.0±0.726 0.9 - 5.7	3.2±990 0.9 - 8.0
Corrected Chlorophyll A						2.10 ± 0.849 0.10 - 4.60	2.08 ± .759 0.20 - 3.90	2.54 ± .960 0.30 - 7.00
Dissolved Material								
Conductivity	278±12.65 295-316	292±10.10 280-310	288±5.53 280-295	287±2.89 280-295	304±7.10 295-320	305±4.58 296-335	304±5.96 296-336	303±8.68 295-334
Chloride	20.8±0.874 19-22				20.5±0.850 19.5-22.0	20.0±0.245 19.5-20.5	19.9±.204 19.5-20.0	20.0±.238 19.5-20.0
Oxygen Saturation	100.0 83.03-142.9				98.9 79.8-144.9	96.5 75.0-111.0	99.0 84-120	100.0 83-121
Transparency								
Turbidity	3.79±4.51 1.3-17	0.366±0.115* 0.30-0.50	0.333±0.153# 0.20-0.50	0.233±.058* 0.20-0.30	3.16±1.60 2.00-7.00	1.30±0.165 0.64-2.00	1.21±.207 0.52-2.20	1.25±.323 0.52-2.80
Secchi Disc		3.5 3.0-5.0	3.8 3.0-5.5	3.8 3.0-5.0		2.7±0.493 1.0-5.7	3.6±1.21 1.1-7.0	3.6±.828 1.7-7.2
Metals								
Iron					0.142±0.084 0.070-0.306	0.06±.0187 0.02-0.26	0.04±.0339 0.01-0.18	0.04±0.051 0.01-0.17
Microbiology								
Heterotrophic bacteria					37 0-1200	3231 250-75,000	2114 500-29,500	1513 250-12,500
Total Coliform/100 ml	9 4-30				14 4-110			
Fecal Coliform/100 ml		3 * 2-4	2 * 2-2	2 * 2-2	3 2-4			
	N = 11	N = 9	N = 9	N = 9	N = 11	N = 18	N = 18	N = 18

* Fewer samples than indicated

Key: Mean±SD
Min-Max

Welland Canal. These levels are safe for aquatic life and indicate only minor impairment of water quality. Objectives of 0.02 mg/l of un-ionized ammonia were never exceeded.

Total Kjeldahl Nitrogen values were all within the 0.1 to 0.5 mg/l range which is indicative of clean water. No differences between Lake Erie, harbour or the Welland Canal station were evident in the data (Figure 18).

Nitrate and Nitrite levels were higher at the Welland Canal station in both years sampled. At the other three stations, concentrations were similar, although higher in 1979 than in 1978. This difference is evident at all stations and appears related to lake conditions rather than influences of the harbour.

Total Phosphorus concentrations were also highest at the Welland Canal station. This station often had levels in excess of 0.02 mg/l which is known to stimulate algal growth. All other stations seldom had values exceeding this concentration of phosphorus. Levels of phosphorus were also higher in 1979 than in 1978. Reason for this cannot be attributed to harbour activities (Figure 18).

Chlorophyll A values were only measured in 1979 and indicate oligotrophic conditions with a tendency to mesotrophy. The highest concentration noted was 8.0 ug/l and this was recorded at Station 1132 in the open waters of Lake Erie. Habour activities were not seen to influence chlorophyll concentrations within Port Colborne.

7.3.2 Dissolved Material

Conductivity was constant at approximately 300 umhos at all stations, in both years. This is the Agreement Objective for conductivity and is a reflection of lake wide conditions. No influence of Port Colborne on conductivity was noted.

Chloride levels were also very consistent at all stations sampled reflecting background conditions. No impact of the harbour was evident.

7.3.3 Oxygen Saturation

Oxygen saturation often exceeded one hundred percent at all stations sampled. Reasons for this condition cannot be detemrined from the available data. Chlorophyll concentrations indicate that algal productivity is not great at this station and unlikely to cause wide fluctuations in oxygen saturation.

7.3.4 Transparency

Turbidity values were also higher inside the Welland Canal and greater in 1979 than 1978. Port Colborne has, however, very low turbidity ranging from 0.2 to 2.0 FTU in the harbour and lake. These levels indicate oligotrophic conditions.

This water clarity is reflected in the Secchi Disc measurements which ranged from 1.0 to 7.2 metres. This indicates very good water quality suitable for water contact recreation.

7.3.5 Metals

Iron samples obtained in 1979 indicate very low levels which were always below Provincial and Agreement Objectives.

7.4 Microbiology

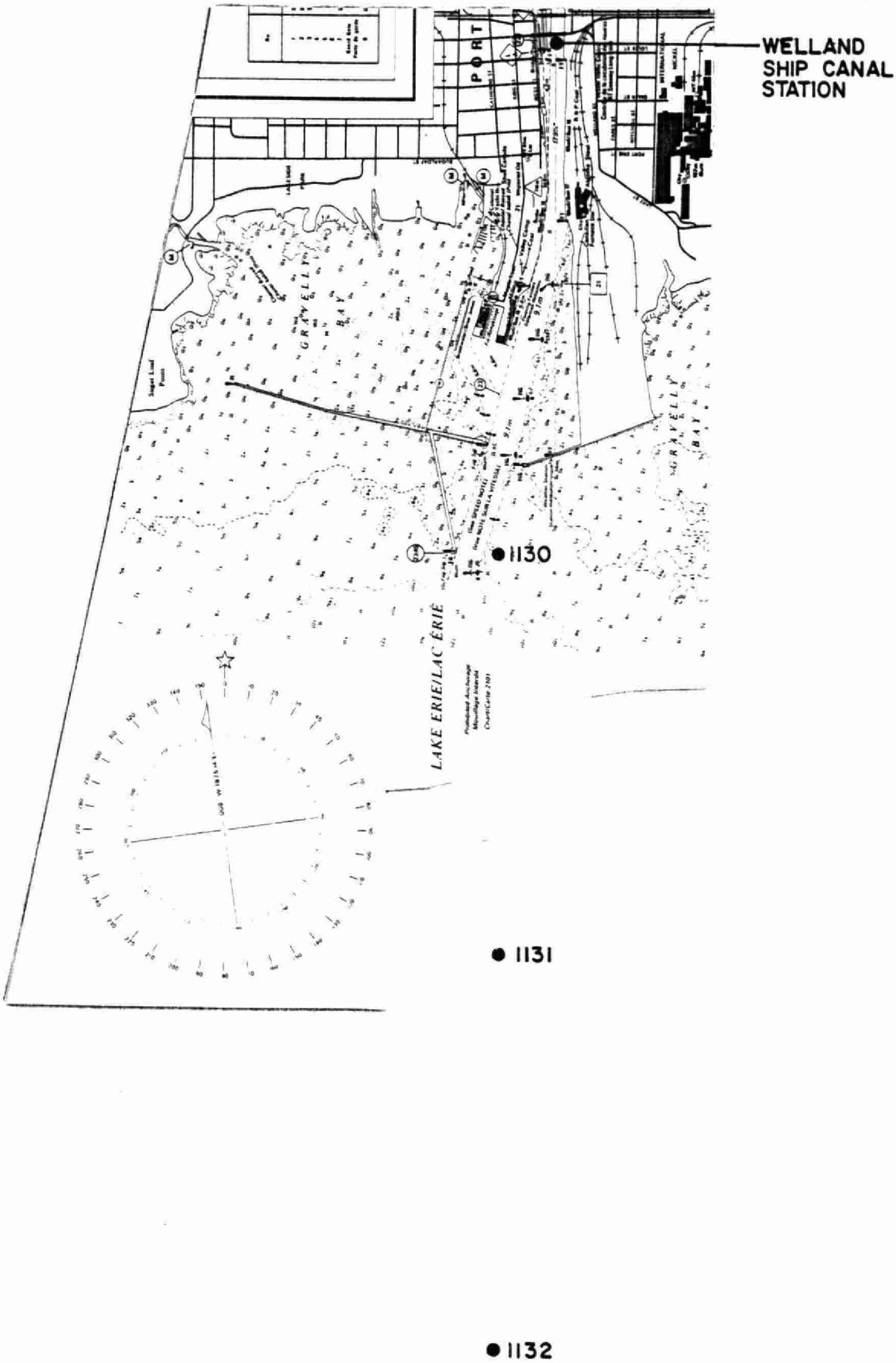
Heterotrophic bacteria samples obtained in 1979 indicate that on average the waters of Port Colborne harbour are oligotrophic. In 1979 numbers of heterotrophs increased from the lake to the harbour indicating greater microbial activity in the in shore waters.

Total and Fecal Coliform data indicate very low numbers of these bacteria and pose no danger to human health. No restrictions on water use are justified on the basis of bacterial numbers in the harbour.

7.5 Summary

In general, Port Colborne water had the best water quality of any harbour investigated. This results to a large extent from flow of water from Lake Erie into the harbour. Thus, conditions in Port Colborne are dependent on Lake Erie water quality and are influenced very little by harbour or watershed development.

Water quality offers good protection to aquatic life, and is suitable for water contact recreation or public water supplies.

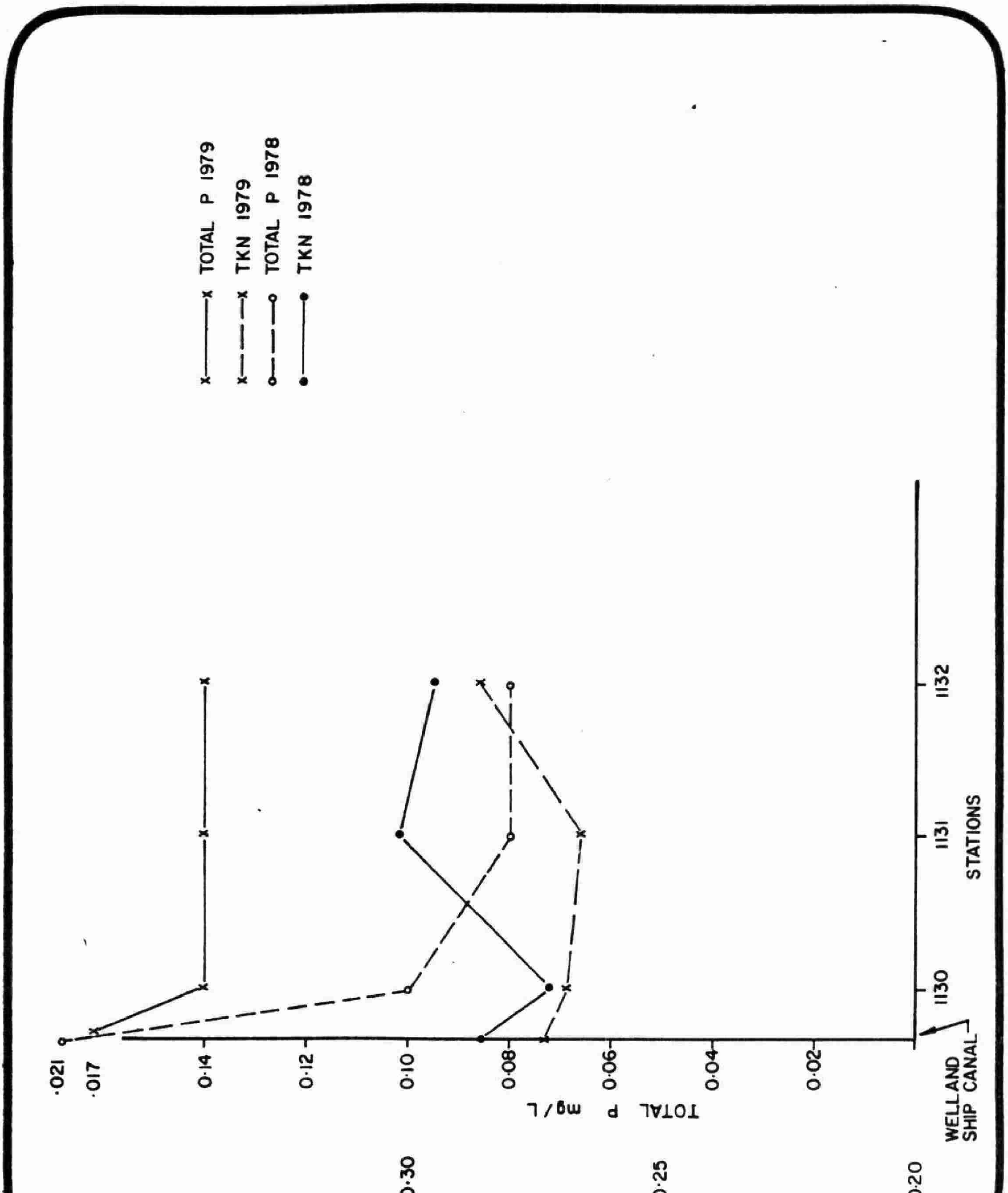


PORT COLBORN

WATER QUALITY STATIONS

SCALE 1: 30,000

FIGURE 18



PORT COLBORNE

COMPARISIONS OF NUTRIENT LEVELS

FIGURE 19

TABLE 9

WATER QUALITY SAMPLING DATES

	1979	1975
Rondeau Harbour	20 - 22/04 20 - 21/08 28 - 29/10	06/07 13/07 06/09 27/09 14/10 26/10 7/11
Port Stanley	21 - 23/04 21 - 23/08 29 - 30/10 03/11	26/07 30/07 31/07
Port Burwell (Big Otter Creek)	Monthly samples for the years 1980 - 1976 taken at Highway 19 Southern Bridge Vienna	
Port Burwell	21 - 23/04 21 - 23/08 29 - 30/10 3/11	
Port Dover	29/04-03/05 25 - 27/06 23 - 27/07 08 - 09/09 12/09	02-04/07 28 - 30/08 07 - 08/10 11/10 03 - 06/11
Port Colborne	08 - 11/05 17 - 19/06 03 - 05/08 28 - 31/08 03/09 30/09 01/10	
Port Colborne Welland Ship Canal	Monthly samples for 1978 taken at First Bridge downstream from Lake Erie	

8.0 BIBLIOGRAPHY

8.0 BIBLIOGRAPHY

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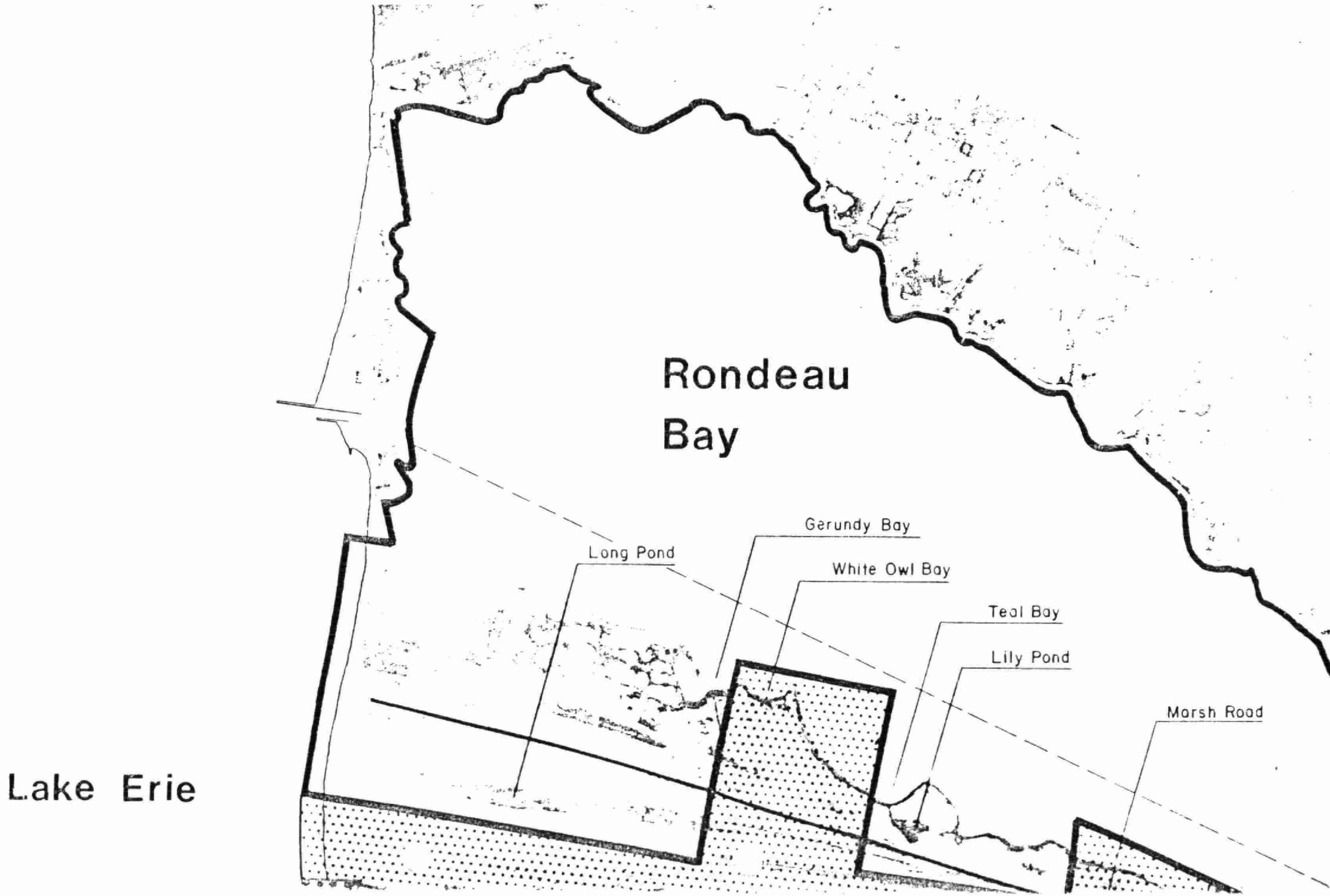
APPENDIX I

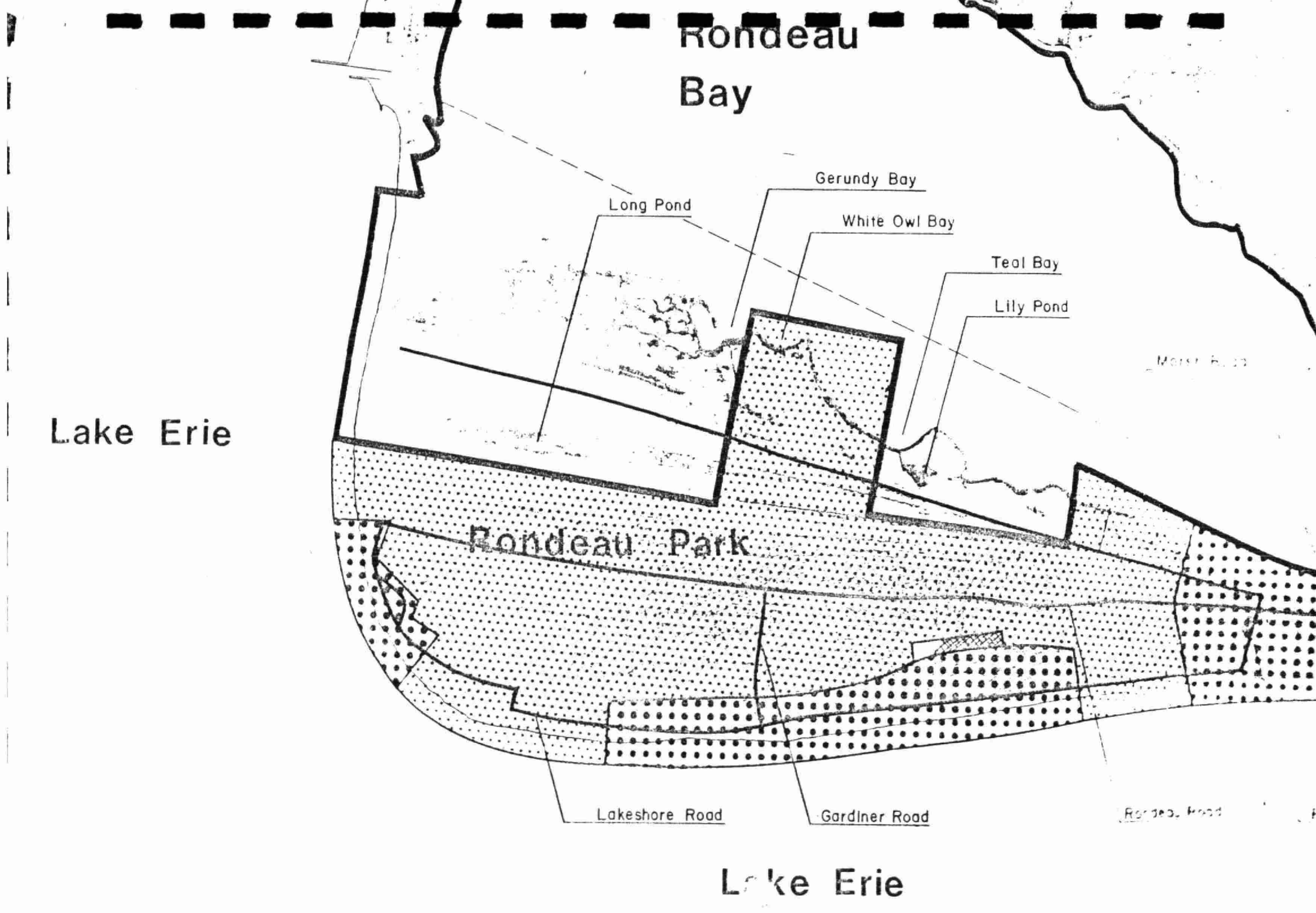
RONDEAU BAY, RECREATION AND ACCESS STUDY

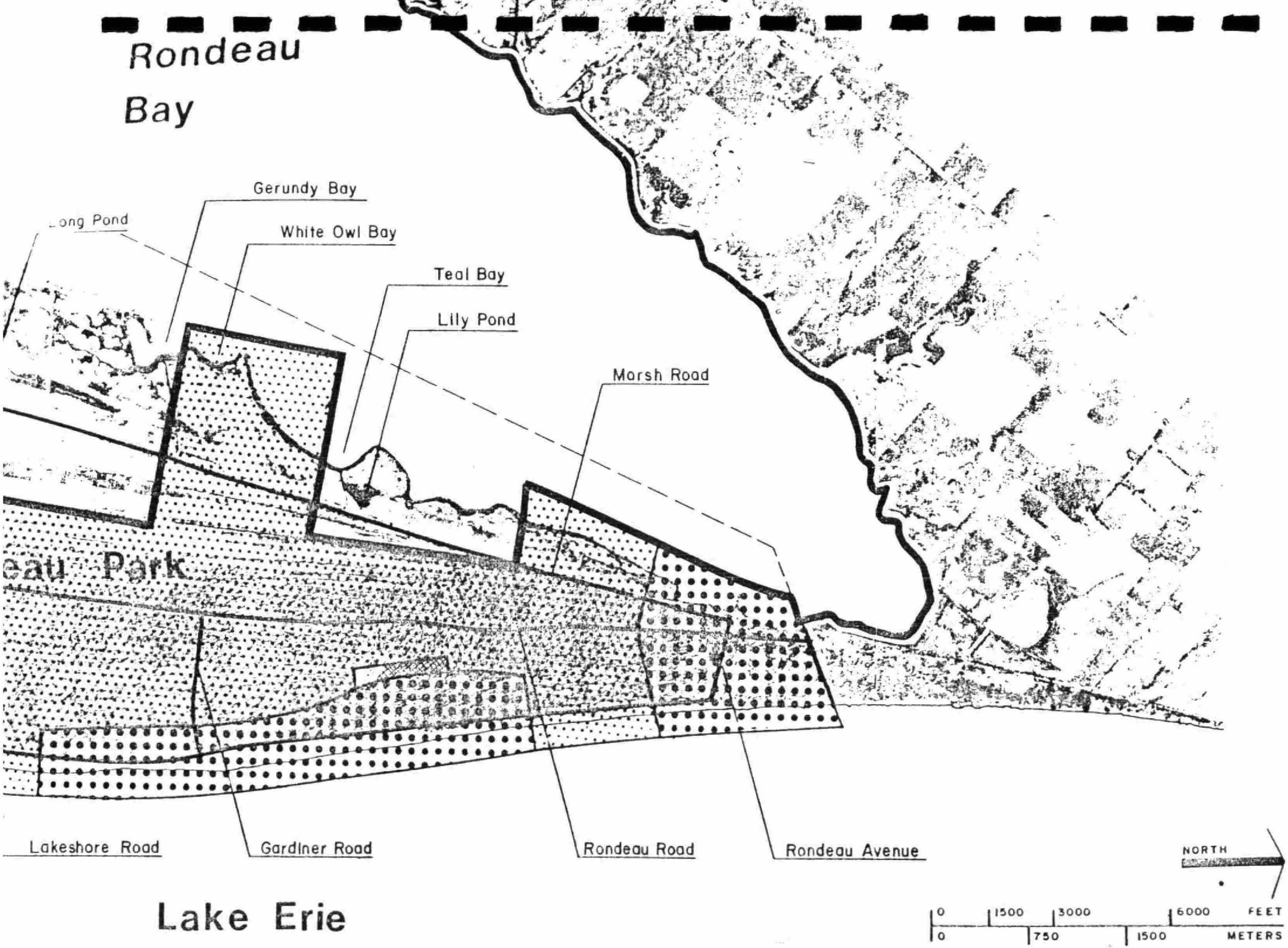
INTRODUCTION

Rondeau Provincial Park covers a total area of 12,104.3 acres* of which 4,870.8 acres are a landform known as the peninsula and 6,788.0 acres are open water named Rondeau Bay. The Bay is not completely surrounded by parkland as is the case with other Provincial Parks, but rather adjoins private land along the entire west shoreline as well as the majority of the north and south shoreline. This unusual relationship has created many problems as technically all the water is within the park or Bay. The junction between the land and water is a very dynamic one and very difficult to define. The very nature of this dynamic edge leads to a number of administrative difficulties in the definition and administrative control of the park boundary. * 445.5 acres are water reserve area in Lake Erie.



Rondeau Bay
Gerundy Bay
Long Pond
White Owl Bay
Teal Bay
Lily Pond
Marsh Road
Lake Erie


Rondeau
Bay
Gerundy Bay
Long Pond
White Owl Bay
Teal Bay
Lily Pond
Lake Erie
Rondeau Park
Lakeshore Road
Gardiner Road
Lake Erie



Rondeau
Bay
Gerundy Bay
Long Pond
White Owl Bay
Teal Bay
Lily Pond
Marsh Road
eau Park
Lakeshore Road
Gardiner Road
Rondeau Road
Rondeau Avenue
NORTH
Lake Erie
0
1500
3000
6000
FEET
0
750
1500
METERS

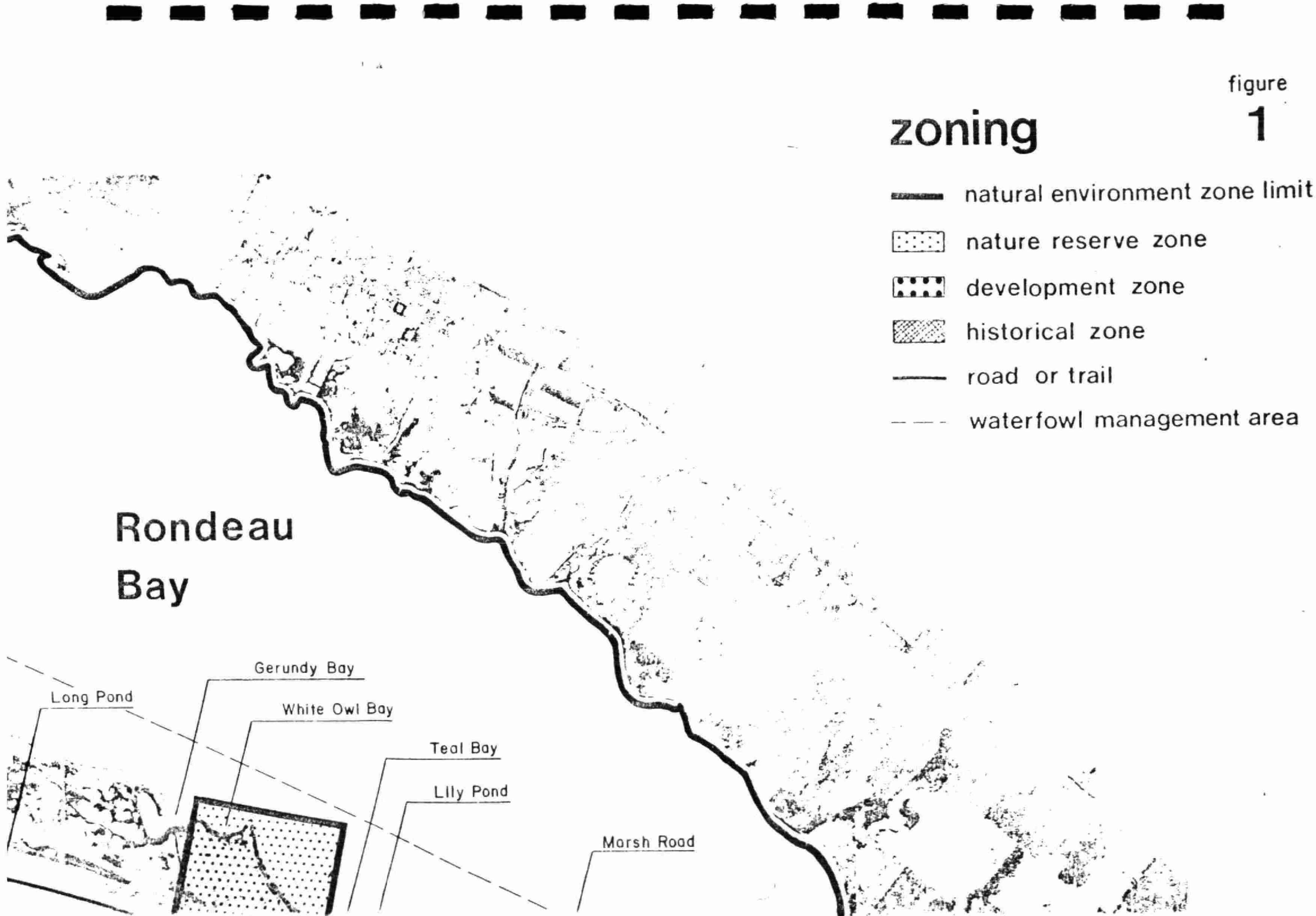


figure
zoning
1
natural environment zone limit
nature reserve zone
development zone
historical zone
road or trail
waterfowl management area
Rondeau
Bay
Gerundy Bay
Long Pond
White Owl Bay
Teal Bay
Lily Pond
Marsh Road

2 BIOPHYSICAL INFORMATION

2.1 Water Quality

A sample station was set up by the Ministry of the Environment in the Erieau Channel for the period January 1970 through December 1971. The Ministry of the Environment has established microbiological criteria for total body contact recreation in natural water bodies at:

Total Coliform - Count not greater than 1000 per 100 ml.

Faecal Coliform - Count not greater than 100 per 100 ml.

During the course of the 24 months of sampling and analysis, the following recorded counts exceeding the M.O.E standards:

Date	Total Coliform Count
*August 13, 1970	9,000
*September 17, 1970	160,000
November 11, 1970	3,400
February 25, 1971	4,900
April 21, 1971	4,000
*June 17, 1971	79,000
*July 14, 1971	3,900
*August 11, 1971	19,000
*September 9, 1971	13,000
October 19, 1971	15,000

*Designates months considered to be more critical for total body contact recreation.

2.2 Fluctuating Water levels

Lake levels have been recorded for Lake Erie in general, from 1916 to the pres Over this period of 61 years, lake elevation has fluctuated from a seasonal maximum of 174.80m (573.5 ft.) in 1973 to a seasonal minimum of 173.02m (567.7 ft.) in 1935, which is a difference of 1.78m (5.8 ft.). This is based on monthly average readings. Seasonal fluctuations from high to low within a given year have frequently been 0.60m (2.0 ft.). There has been no consistent pattern or cycle of fluctuation, over the 61 year recording period which will allow prediction of future level variations. The range of seasona fluctuation of 0.45m (1.5 ft.) to 0.60m (2.0 ft.) between a seasonal high in June and seasonal low in February has been relatively consistent.

Throughout the boating season, from approximately May 24 to October 10, the fluctuation in water level is an average of 0.25m (0.8 ft.) with an average monthly high in June of 174.04m (571.0 ft.) and an average monthly low in October of 173.79m (570.2 ft.). It must be remembered that these figures are averages and are not to be considered as standards for construction. The combination of the fluctuating water elevations of Lake Erie, and the very gentle gradient of this harbour bottom and its surrounding land, has very dramatic affects upon wildlife and recreation in the Bay. A minor change in lake levels can bring about significant changes in vegetation and wildlife habitat of great lateral extent. These changes are manifested in major lateral shifts of aquatic vegetation communities with resulting boating restrictions through aquatic growth. During the low water period about 1964, channels were cleared with an underwater cutter to allow boating and sailing in the harbour. A major drop in lake levels would leave most marina facilities high and dry and require extensive dredging of dock areas and channels to deeper water in order to continue operation.

For the incomplete information available about water depths and bottom contour it appears that the east shore of the harbour drops away at a steeper gradient than does the west shore. Approximately 250.0m (820.2 ft.) from the east shore, the bottom slopes away to a depth of 2.5m (8.2 ft.) whereas to achieve the same depth on the west shore one would have to travel an average of 750.0m (2460.6 ft.) (using August 1977 water level of 174.2m or 571.5 ft.).

This data indicates that it would be disadvantageous to develop any new facilities on the west shore of the harbour and that any design for water oriented facilities must consider not only yearly fluctuations in water levels but also fluctuations occurring over the summer recreational season.

2.3 Sedimentation

Up until the time that core samples had been taken and analysed by Environment Canada in August 1977, Rondeau Bay was thought of by many to be gradually infilling with sediment with some predictions of 100 years or more before it would be filled. The analysis of the core samples suggests that the average rate of sedimentation over the past 127 years is about 2.6 mm./year which is very close to the average for all of Lake Erie. This does not appear to pose a major threat to Rondeau Bay in terms of its future use.

The sediment appears to be very mobile and is resuspended when disturbed by wind/wave action or powerboats etc.. There is apparently little buildup of sediment along the west shore of the Bay (approx. 50 mm) which would indicate that sediment introduced by the creeks along the west shore settles in the deeper water towards the centre of the Bay.

Although sedimentation of Rondeau Bay at its present rate is considered to be a natural process by the Ministry of Natural Resources, there are a number of instances of poor agricultural land-use and construction practices along creek channels which contribute to accelerate the rate of sedimentation. There appears to be little control in terms of existing legislation but there seems to be a need for simple guidance from the Ministry and the Lower Thames Valley Conservation Authority as well as the Ministry of Agriculture and Food.

2.4 Bottom Conditions

There is presently no detailed information available concerning soil types at the bottom of Rondeau Bay. Some samples where taken this year by Environment Canada and by the Ministry of Natural Resources, Aylmer District Fish and Wildlife Section, but the amount of data available is very minimal when considering the size of Rondeau Bay. Conclusions should not be drawn solely using this information.

The following is a list of bottom types sampled in August 1977, at the 1975 Fisheries Survey Stations within Rondeau Bay. See figure 2.

Approximate longitudes and latitudes of Stations sampled:

Station #1	Clay Muck	42^{o} 19' 17" lat.	81^{o} 51' 46" long.
Station #2	Sandy clay bottom	42^{o} 19' 27" lat.	81^{o} 52' 53" long.
Station #3	Clay with sand	42^{o} 19' 44" lat.	81^{o} 51' 01" long.
Station #4	A thick layer of organic detritus	42^{o} 17' 28" lat.	81^{o} 51' 49" long.
Station #5	Muddy sand bottom	42^{o} 16' 44" lat.	81^{o} 52' 40" long.
Station #6	Sand	42^{o} 15' 32" lat.	81^{o} 54' 05" long.

Station #7	Clay	42^{o} 17' 10" lat.	81^{o} 53' 52" long
Station #8	Clay	42^{o} 16' 26" lat.	81^{o} 59' 53" long
Station #9	Largely a thick layer of organic matter	42^{o} 17' 02" lat.	81^{o} 52' 07" long.

The samples taken by the Ministry general coincide with the bottom conditions analysis by Environment Canada upon 12 transects of soundings they took throughout the Bay. Bottom types were plotted according to the reflection density recorded by the soundings.

Reflection Type	Associated Bottom Type
Thin, dense reflection with 1-2 multiples and a smooth, undulating surface	- muddy sand to sand
Moderately thick, dense reflection with 1 multiple and smooth, inclined surface	- sandy mud
Thick, diffuse reflection generally with no multiple and a flat surface; but also with an occasional multiple and/or undulation.	- silt
Thick, dense reflection with no multiple and a flat surface	- clay.

2.5 Aquatic Vegetation

The types and amounts of aquatic vegetation growing in Rondeau Bay appear to vary from season to season and even from month to month, with changing water levels and water chemistry. Apparently in August of 1977, the surface aquatic plants virtually disappeared, and numerous theories on the reasons have been formulated by local residents, but none of the explanations seem to satisfy all of the complexity of biological systems represented within Rondeau Bay.

During August of 1977 the Ministry of Natural Resources Aylmer District Fish and Wildlife Section observed aquatic vegetation growing at the 1975 Fisheries Survey Stations within Rondeau Bay, see Figure 2, and produced the following list of species and observations by station:

Station #1 - Date Sampled - August 23, 1977

Depth = 2.52 meters

Types of plants observed:

1. Chara
2. Potamogeton vaginatus
3. Najas flexis
4. Myriophyllum verticillatum

Observation - Very little plant life observed, Potamogeton vaginatus (Tarez) most abundant though little of that present.

Station #2 - Date Sampled - August 23, 1977

Depth = 1.18 meters

Types of plants observed:

1. Chara
2. Vallisneria americana
3. Najes flexilis

Observations - very little plant life observed, (tapograss), Vallisneria americana (Michx) most commonly found though that found was in very poor condition.

Station #3 - Date Sampled - August 15, 1977

Depth = 1.062 meters

Types of plants observed:

1. Potamogeton vaginatus
2. Ceratophyllum demersum

General Observations - very little species variety observed in this area and those plants that were found were sparsely scattered over the bottom.

Station #4 - Dates Sampled - August 1, 1977 to 3, 1977

Depth = 0 to .660 meters

Types of plants observed:

1. Potamogeton filiformis
2. Sagittaria sp.
3. Leucospors multifida
4. Eupatorium perfoliatum
5. Vallisneria americana
6. Potamogeton epihydrus
7. Utricularia vulgaris
8. Myriophyllum verticillatum
9. Myssa sylvatica var. biflera
10. Nymphaea odorata
11. Potamogeton vaginatus
12. Nyssa sylvatica var. biflora
13. Zizania aquatica

General Observations - There are many different species of plants located in this bay area and the species composition varies depending on the

3 EXISTING RECREATIONAL USES OF RONDEAU BAY

3.1 Existing Recreational Activities

Rondeau Bay is unquestionably one of the better opportunities for the enjoyment of the majority of water oriented recreational activities within Southwestern Ontario and is certainly the prime opportunity within the study area. The study area was determined by a one hour travel time radius (by automobile) centred at the entrance to Rondeau Provincial Park. A one hour travel time by automobile is considered to be a reasonable maximum amount of time a user would spend in order to travel to participate in a day-use recreational activity.

The following is a seasonal list of the recreational activities that commonly take place within Rondeau Bay:

Spring
- Angling
- Boating (power & non-power)
- Nature observation

Summer
- Angling
- Boating (power & non-power)
- Nature observation
- Swimming
- Waterskiing

Fall
- Angling
- Boating (power & non-power)
- Nature observation
- Waterfowl hunting

Winter
- Ice fishing
- Ice boating.

3.2 Rondeau Gate - Boat Survey

Over the course of 39 days between July 29 and September 5 of 1977, a survey was taken of all parties entering Rondeau Provincial Park,at the control gate, who were transporting a boat of any type into the park. This survey was undertaken to obtain figures on the numbers, types and uses of boats launched on a day-use basis from the park. The following are the actual figures and percentages of the gate survey:

Boat Survey	No. of Boats	Percentage
Total Boats through Park Gate	393	100%
Visitation to Rondeau		
• First Visit	71	18.1%
• Return Visit	322	81.9%
Means of Transport		
• Cartop	92	23.4%
• Trailer	301	76.6%

Boat Survey	No. of Boats	Percentage
Type of Boat		
• Sailboat	35	8.9%
• Canoe/Kayak	64	16.3%
• Rowboat	25	6.4%
• $\leq$ 10 H.P.	33	8.4%
• $\geq$ 10 H.P.	236	60.0%
Type of Boating Activity		
• Pleasure Sightseeing	263	67.0%
• Fishing	135	34.4%
• Water Skiing	100	25.4%
• Sailing Race	12	3.1%
Major Boating Area		
• Rondeau Bay	290	73.8%
• Lake Erie	110	28.0%

The survey indicates an obvious pattern of boaters who use Rondeau Park as a starter point for their pursuit of recreational boating. Rondeau Park receives alot of return use for launching of which the majority of people launch and stay within Rondeau Bay. The most popular boat is the over 10 H.P. runabout and the most popular pastime with boats is pleasure boating and/or sightseeing.

During the 39 day survey the heaviest use of Rondeau Park for boat launching purposes was a Monday holiday, August 1, 1977 and a Sunday, August 14, 1977. Both days recorded 35 watercraft transported through Rondeau gate. The lightest use was a Tuesday, August 30, 1977 and a Thursday, September 1, 1977. Both days recorded one lone boat transported into the park. The average number of boats through the gate was 10.1 boats per day.

3.3 Resource Evaluation

3.3.1 Boat Angling

Rondeau Bay has outstanding regional significance with respect to boat angling. The Bay ranks second only to the Lake St. Clair Sport Fishery. It is the only area along the Lake Erie shoreline, within one hour travel time, that offers reasonably successful fishing when considering species of fish caught and rod hours spent per fish. Each fishing season, especially at the end of June through July Rondeau attracts fishermen from all over southwestern Ontario and the north central United States to fish for black bass.

Fishing at Rondeau Bay provides one of the main sources of income for many area people. Most anglers use privately owned/operated facilities, ie: bait, boat rentals, accommodation etc. thus making it a very important piece of the local

economy.

Rondeau Bay is habitat for a large diversity of fish species, some of which are uncommon to any other waters within the study area.

3.3.2 Ice Fishing

Rondeau Bay is as significant for ice fishing as it is for boat angling due to the success of anglers and the variety of fish caught. Lake St. Clair again has to rank as the most popular ice fishing area within the study limits, being far more developed in terms of support facilities.

3.3.3 Pier/Dock Angling

Rondeau Bay is one of few opportunities for dock angling in this part of Ontario. Although dock fishing is not considered to be a very successful means of catching the most desirable sport fish, namely largemouth bass and northern pike, it is never-the-less a very popular pastime for many people. It is not uncommon to have people drive into the park in the evening, set up a light and chair on the dock and fish all night, often without catching anything. There are usually 3 to 7 people fishing from the park dock every evening so it would appear that fishing from the dock is more of a social event than a sport. The most common species caught are bluegill and yellow perch.

3.3.4 Shore Fishing

Rondeau Bay is considered to be one of the better opportunities for shore fishing within the study region. There are no other shore fishing opportunities along the Lake Erie shoreline from Pelee National Park to Port Stanley that offer the degree of success as does Rondeau Bay. Although shore fishing is considered to be a far less productive method of angling than boat angling it is a very popular form of recreation in the Rondeau area especially with the black population in Shrewsbury. The major limiting factor of shore fishing on the Bay is the inaccessability of the majority of shoreline to the general public due to private land ownership and the marshy shoreline character.

The shore fishing survey indicates that shore fishing along most of the east shore of the Bay is not a very successful method of taking the more desirable sport species, namely large/smallmouth bass and northern pike. For example area D2, designated by the map on the accompanying page, required an average of 150.2 rod hours per largemouth bass caught. The majority of fish taken were pan fish which are not considered a true sport fish but are for many, a very desirable eating fish.

3.3.5 Powerboating

Although there are presently many good opportunities for all types of power-boating within the area, Rondeau Bay is a better quality boating experience than most. The attractiveness of the Bay for all types of boating appears to be the assurance of relatively calm water in most weather conditions and to some extent, the Bay's visual sense of enclosure. Given a choice, it seems that most boaters prefer Rondeau Bay as opposed to Lake Erie. The Rondeau gate - boat count indicated that 73.8% of boaters who launched their craft from Rondeau Park stayed within the waters of Rondeau Bay in order to carry out thei major recreational interest.

3.3.6 Canoeing

There are presently many good quality canoeing opportunities throughout the study region and although Rondeau could not be classed as an outstanding canoe-ing experience it is never-the-less an unique opportunity. The most popular activity of the Rondeau canoeists is the exploration of the network of ponds and old dredgecuts within the marsh areas. The pleasant natural setting with its abundance of wildlife along with the calm waters combine to attract many canoe and nature enthusiasts to the marsh/Bay area. The Rondeau Gate-Boat Survey indicated that canoes are the second most popular type of boat launched from the park (16.3% of total boats launched).

3.3.7 Waterfowl Hunting

Rondeau Bay including its marsh area is one of two locations for public waterfow hunting within the study region and is undoubtably one of the more outstanding experiences within Southwestern Ontario. The other public hunting area within the Rondeau study region is Fingal Wildlife Management area which only provides for a very limited number of hunters and is not the high quality hunting experience that is associated with Rondeau.

3.3.8 Ice Boating

The nature of the sport of ice boating is one of complete dependence on ice and weather conditions. Rondeau Bay is one of the more dependable sites of good ice conditions and is considered to be the best ice boating opportunity within the study area. The other few locations of ice boating activity within the area do not offer the frequency of good conditions as normally occurs on Rondeau Bay.

3.3.9 Sailing

Although good quality small craft sailing is enjoyed on many water bodies throughout the study area, few compare with the near ideal conditions which are common on Rondeau Bay. Pleasure sailing and sailboat racing are both very popular recreational pastimes on Rondeau Bay as it is well suited for small craft sailing because of its protection from Lake Erie and its relatively large surface area. The short fetch insures calm water in most wind conditions which is an ideal situation for sailing. For the amateur sailor, the shallow water depths of most areas of the Bay are a psycological comfort, as righting an overturned boat is not a major problem when one can stand on the bottom.

3.3.10 Scuba Diving

There appear to be no water bodies within the study area that are well suited for scuba diving. Rondeau Bay is probably one of the least attractive areas for scuba diving because of high water turbidity, abundance of aquatic vegetation, shallow water depths and presence of powerboats.

3.3.11 Swimming

One of the major problems with swimming in natural water bodies within the study area is poor water quality. As a result most beaches are populated by people with a major interest in sunbathing as opposed to swimming. Rondeau Bay is not considered by most to be desirable water in which to swim because of high bacterial counts and more obvious, its high turbidity, but there are many who like the warm water temperature and shallow depths and frequent the life-guarded dock.

3.3.12 Waterskiing

The conditions that are beneficial for powerboating and sailing are also ideal for waterskiing. The presence of relatively calm water on some part of the Bay during most weather conditions makes a waterskiing trip to the park, trailering a boat, less of a risk. Other sites are good for waterskiing on windless days, but these days are few and far between.

3.3.13 Nature Observation

Although it is very difficult to judge the quality of observation experience of one area as opposed to another, even with a detailed biological inventory, by virtue of overall size and amounts of natural areas, it would seem that Rondeau Bay is probably the most satisfying site within the study area in which to observe a wide diversity of natural forms of life. There are presently found in Rondeau Bay, a number of different species of birds, mammals, fish etc., some of which are uncommon anywhere else within the study area.

4.2 EXISTING MARINA FACILITIES

ONTARIO RECREATIONAL SURVEY INVENTORY
AUGUST, 1975

	COMMERCIAL ESTABLISHMENTS OFFERING SERVICES FOR BOATING										
	BURKE'S CABINS	BROWN'S CABINS	GRAHAM'S BOATS & BAITS	MAXWELL'S CABINS	HOWELL'S CAMP	PHILLIP'S BAY-VIEW COTTAGES	MOOT'S TOURIST CAMP	ERIEAU MARINA	RONDEAU BAY MARINA LTD.	POINTAUX PINS YACHT CLUB	TOTALS
Boat Rentals											
NO. AND TYPE OF BOAT											
CANOES	3							12	3		18
ROWBOATS/KAYAKS	20		7		8		10	5			50
SAILCRAFT											0
RUNABOUT < 10 HP.		17	10		6		9	5	6		53
RUNABOUT < 18 FT. > 10 HP.							1				1
> 18 FT.											0
Mooring Facilities											
PERMANENT DOCK	●			●		●	●	●	●	●	7
REMOVABLE DOCK	●	●			●						3
MAXIMUM DRAUGHT (FT.)	3	7		4	5	7	2	9	5	5	
TYPE OF BOAT HANDLED											
CANOE/KAYAK/ROW	●	●		●							3
SAILCRAFT < 18 FT.		●									1
RUNABOUTS < 18 FT.	●	●		●	●	●	●	●	●	●	9
> 18 FT.		●						●	●	●	4
POTENTIAL BOATS	31	50		10	26	8	40	166	35	12	378
TYPE OF MOORING											
PARALLEL DOCKING		30				8	2	60	1		101
BOW IN/STERN TIE	27			10	6		38	70		12	163
SLIP SPACES								36	34		70
BUOY MOORING	4	20			20						44
SPACES USED BY RENTALS							3	20	9		57
NO. OF DRY SPACES							5				5
% PUBLIC USE	0	0		0	0	0	25	100	100	100	
Boat Launching											
LAUNCHING RAMP	●	●	●	●	●	●	●	●	●		9
MECHANICAL LAUNCH											
LAUNCHED AT ONE TIME	1	1	1	1	1	1	1	1	1		9
% PUBLIC USE	0	0	75	0	0	0	50	100	100		

APPENDIX II

LOWER THAMES VALLEY CONSERVATION AUTHORITY

RONDEAU BAY WETLAND ACQUISITION STUDY

RONDEAU BAY WETLAND ACQUISITION STUDY

LOWER THAMES VALLEY CONSERVATION AUTHORITY

1980

DISCUSSION

I) Wetland Delineation

A wetland is usually defined as an area where water of a depth of up to 2 metres covers the land for all or part of the year. For the purpose of this study, only those properties which satisfy these conditions and are assessed land taxes by the Township of Harwich are considered.

Mapping of the wetland areas was accomplished using aerial photos of the bay when relatively high water levels existed (spring of 1977). The zoning by-law map for Harwich Township was also of assistance as it was found that the zones designated Environmental Protection (EP.1) along the northwest shore of Rondeau Bay closely corresponded to those areas inundated in the 1977 aerial photos.

In this manner, those areas which are likely to, at some time, support wetland communities were delineated, and are illustrated in Figure 2.

II) Area Description

The study area shown in Figure 2 was found to be dominated by the Unvegetated Cover Type as defined in the wetland classification system used by Lemay (1979). This cover type consisted primarily of open water and submerged vegetation with several mud flats evident.

Second in prominence was the Emergent Cover Type which was dominated by Cattails (*Typha* spp.), and various grass and sedge species. The other wetland cover types, namely Tree Cover, Shrub Cover, and Floating Cover were all represented, but to a lesser extent in the study area.

The predominance of the Unvegetated Cover Type is probably due to the high water levels present at the time of the study and for several years prior to the study. Taking into account the seasonal fluctuations of about 0.5 metres, the water level of Lake Erie averaged approximately 174.4m in 1979 compared to an average over the past 60 years of approximately 173.9m. The highest and lowest levels recorded for Lake Erie, which directly affect Rondeau Bay levels, were 174.8m. and 173.0m. in 1973 and 1935 respectively.

The habitat provided by the combination of cover types present in the study area is suitable for the survival of

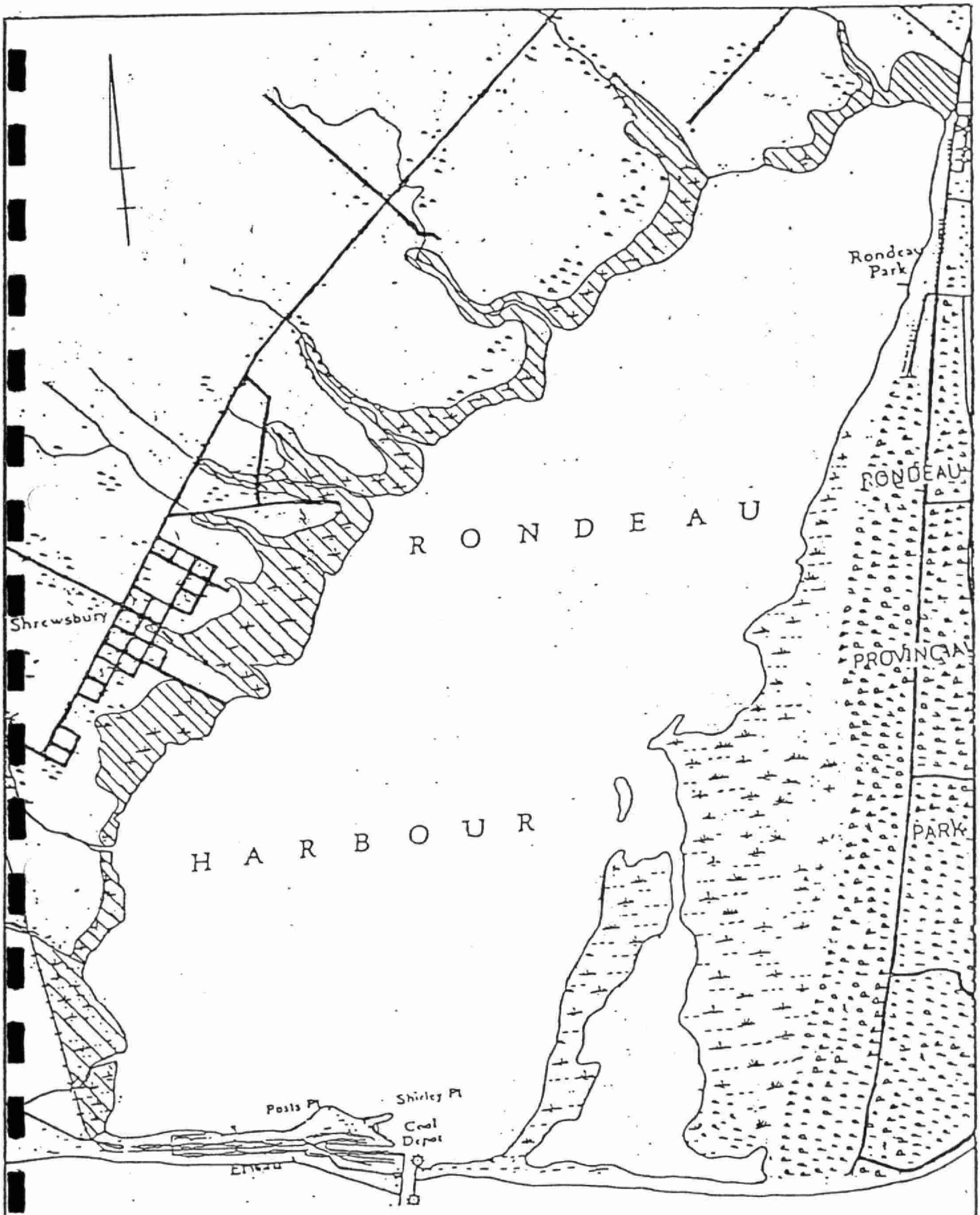


Figure 2

STUDY AREA

several rare plant and animal populations. Herptiles such as the Eastern Spiny Softshell Turtle (Trionyx spiniferus spiniferus), the Spotted Turtle (Clemmys guttata) and the Eastern Fox Snake (Elaphe vulpina gloydi), are all residents of this area. It should be noted that these species are officially or unofficially recognized as being endangered.

The study area also provides habitat for waterfowl nesting and staging, as well as the spawning, nursing and feeding activities of such gamefish as Northern Pike (Esox lucius) and species of Bass and Perch. In addition, several species of panfish are also present in the area. Waterfowl hunting and sport fishing are both important to the local economy.

The wetland communities serve other functions such as filtering and improving the quality of water, providing habitat for non-game birds (shorebirds, herons and raptors), and providing a source of recreation for naturalists and photographers.

As previously noted, it is the combination of cover types present in the study area which provide the various habitats and activities mentioned. A combination consisting of more emergent cover and less unvegetated cover, as evident in typical marshland, would undoubtedly provide for a more productive community. A community of this sort is present in the study area during times of low water levels as is evident on several old aerial photos. However, the present conditions appear to be ideal for the Eastern Spiny Softshell Turtle, several of which were noted during field work in the study area.

III) Land Ownership

Land ownership in the study area was found to be of two basic types, blocks, consisting entirely of wetland and areas where the study area is only a small part of the property. Most of the latter types are farms which have a wetland fringe fronting on Rondeau Bay. Land ownership is illustrated in Figure 3 while the accompanying Table gives the names of the landowners at the time of the study.

Some discrepancies have occurred over land ownership in the study area due to a lack of clearly defined deeds and surveys. Further complications have resulted from the changing water levels. As a result, several properties described in Figure 2 were under close to a metre of water at the time of

the study. It might therefore be argued that these properties belong to the Ontario Ministry of Natural Resources, as Rondeau Bay is a part of Rondeau Provincial Park.

CONCLUSION

Due to varying water levels of Lake Erie, all parts of the study area, at one time or another, serve one or more of the important functions provided by wetlands. As protection of this wetland through the Harwich Official Plan is minimal, and the contention that the wetland is part of Rondeau Provincial Park rather tenuous, it is recommended that the Authority continue in its efforts to acquire land in the area. This is the only way to ensure the preservation of this valuable wetland.

It is impossible to identify priority areas for acquisition on the basis of habitat quality as the habitat is drastically altered by changing water levels. However, it is recommended that those areas where entire blocks of marshland are individually owned be given priority as these might be most prone to misuse and development. Areas at the extreme northeast and southwest ends of the study area, as well as, those in the vicinity of Shrewsbury, should also be given top acquisition priority.

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